Sex and Age – Specific Distributions of Sea Ducks Wintering in the Strait of Georgia, British Columbia: Implications for the Use of Age Ratios as an Index of Recruitment

S.A. Iverson, W.S. Boyd, H.M. Regehr, M.S. Rodway

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Sex and age–specific distributions of sea ducks wintering in the Strait of Georgia, British Columbia: Implications for the use of age ratios as an index of recruitment

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ABSTRACT

Management of sea duck populations in North America has been hampered by a lack of effective population monitoring tools. In this study, we used sex and age ratios calculated from direct visual counts to assess the demographic structure of the nine most common sea duck species wintering in the Strait of Georgia, British Columbia: Black Scoters (*Melanitta nigra*), Surf Scoters (*M. perspicillata*), White-winged Scoters (*M. fusca*), Harlequin Ducks (*Histrionicus histrionicus*), Barrow's Goldeneye (*Bucephala islandica*), Common Goldeneye (*B. clangula*), Bufflehead (*B. albeola*), Common Mergansers (*Mergus merganser*), and Red-breasted Mergansers (*M. serrator*). Shore-based surveys were conducted along 49 1-km transects during February 2003 and 62 transects in 2004. Our objectives were to estimate species' sex and age-specific abundance, evaluate distribution patterns, and determine whether multiple species surveys are suitable for monitoring annual variation in sea duck recruitment rates.

Results indicated that adult sex ratios were male-biased, with a particularly strong skew evident among Black and Surf Scoters (3.5 and 2.3 males per female, respectively). With respect to male age ratios, the proportion first year male was low for the five species for which they could be estimated (M_{1Y}/M_{TOTAL}: 0.14 ± 0.03 SE for Black Scoters; 0.07 ± 0.02 SE for Surf Scoters; 0.08 ± 0.02 SE for Harlequin Ducks; 0.07 ± 0.01 SE for Barrow's Goldeneye; 0.12 ± 0.02 SE for Common Goldeneye). This result was not surprising, given that sea duck life-histories are characterized by female-only parental care, high adult survival, and low annual productivity. However, for some species the age ratios we documented would not be sufficient to compensate for adult mortality, raising the possibility that detection biases or segregated distribution patterns preclude reliable population-level age ratio estimation. We cannot reject the possibility that unknown numbers of first year males are misidentified due to the difficulty of visually distinguishing individuals in exceptionally adult male or female-like plumages, and that male age ratios underestimate recruitment. Some segregation of the sex and age classes among habitat types was apparent within the Strait of Georgia, but the magnitude of distributional biases was generally quite small. Potential distributional biases at larger spatial scales should be investigated.

We conclude that winter sex and age ratio surveys are a reliable, inexpensive means of gathering important demographic data. However, several important considerations must be made before incorporating such data in population models. These include: quantifying the degree to which age ratios might be underestimated; determining the validity of using male age

ratios to infer female age ratios and ensuring that estimates are drawn representatively from the population as a whole; and determining the spatial scale at which wintering aggregations must be studied to ensure valid inferences about population processes.

RÉSUMÉ

La gestion des populations des canards de mer en Amérique du Nord souffre d'un manque d'outils de surveillance efficaces. Dans cette étude, nous avons utilisé les rapports des sexes et les rapports immatures-adultes calculés à partir des décomptes visuels directs pour évaluer la structure démographique des neuf espèces les plus communes de canards de mer qui hivernent dans le détroit de Georgia, en Colombie-Britannique : macreuses noires (*Melanitta nigra*), macreuses à front blanc (*M. perspicillata*), macreuses brunes (*M. fusca*), arlequins plongeurs (*Histrionicus histrionicus*), garrots d'Islande (*Bucephala islandica*), garrots à oeil d'or (*B. clangula*), petits garrots (*B. albeola*), grands harles (*Mergus merganser*) et harles huppés (*M. serrator*). Des relevés à terre ont été effectués en suivant 49 transects de 1 km en février 2003 et 62 transects en 2004. Notre objectif était d'estimer l'abondance des spécimens selon leur âge et leur sexe, pour chaque espèce, d'évaluer leur distribution et de déterminer si des relevés multiples permettent de suivre correctement les variations annuelles du taux de recrutement chez les canards de mer.

Les résultats indiquent que le rapport des sexes était en faveur des mâles, avec un déséquilibre marqué dans le cas des macreuses noires et des macreuses à front blanc (3,5 et 2,3 mâles par femelle, respectivement).Pour ce qui est du rapport immatures-adultes des mâles (M_{1an}/M_{TOTAL}), il était faible pour les jeunes mâles d'un an des cinq espèces : 0,14 ± 0,03 pour les macreuses noires; 0,07 ± 0,02 pour les macreuses à front blanc; 0,08 ± 0,02 pour les arlequins plongeurs; 0,07 ± 0,01 pour les garrots d'Islande; 0,12 ± 0,02 pour les garrots à œil d'or). Ces résultats ne sont pas surprenants puisque seules les femelles prennent soin des petits chez les canards de mer, que le taux de survie des adultes est élevé et que la productivité annuelle est faible. Toutefois, pour certaines espèces, le rapport des sexes que nous avons mentionné, s'il était réel, ne serait pas suffisant pour que la mortalité des adultes soit compensée et il est donc possible qu'il existe des erreurs systématiques dans les observations ou que des anomalies de distribution empêchent l'estimation fiable du rapport des sexes au niveau des populations en question. Nous ne pouvons pas rejeter la possibilité qu'un nombre inconnu de mâle d'un an soient mal identifiés, compte tenu de la difficulté de distinguer à vue les mâles des femelles à cet âge, et que le rapport immatures-adultes pour les mâles sous-estime le recrutement. Les différents types d'habitat dans le détroit de Georgia semblent avoir une légère influence sur l'effectif des classes de sexe et d'âge mais cet effet reste généralement assez faible. Il serait nécessaire d'étudier l'éventuel existence d'effets plus marqués de l'environnement sur les distributions à des échelles spatiales plus grandes.

Nous concluons que les relevés d'hiver visant à calculer les rapports des sexes et les rapports immatures-adultes constituent une méthode fiable et économique de recueillir des données démographiques importantes. Il faut cependant faire plusieurs mentions importantes avant d'incorporer ces données dans les modèles démographiques. Notamment : quantifier le degré maximal de sous-estimation des rapports des sexes; déterminer la validité d'utiliser les rapports immatures-adultes pour les mâles pour déduire les rapports équivalents pour les femelles et s'assurer que ces évaluations sont extraites de manière représentative en utilisant l'ensemble de la population; déterminer l'échelle spatiale à laquelle les rassemblements hivernaux doivent être étudiés pour bien comprendre les processus démographiques.

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1 INTRODUCTION

Recent evidence has indicated that sea duck (Anatidae: Mergini) populations are declining in North America (Sea Duck Joint Venture 2001, Goudie *et al.* 1994). The reasons for these declines are unknown and detailed ecological data are needed to ascertain both the mechanisms underlying population changes and the life stages at which they are occurring. Monitoring efforts that incorporate demographic data can lend important insight into population processes; however, management of North American sea duck species has been hampered by a lack of effective population monitoring tools.

Recruitment, the process by which young birds are added to the breeding population, is a crucial component of avian demographics. In waterfowl populations, recruitment is typically inferred using techniques such as pair-brood ratios (e.g. Kirby 1980, Rumble and Flake 1982), nesting success rates (e.g. Milne and Reed 1974; Klett *et al.* 1988, Traylor *et al.* 2004), and age ratios based on wings turned in by hunters (e.g. Bellrose *et al.* 1961). However, these techniques have been of limited value for sea duck species for several reasons. First, the core ranges of many sea ducks falls outside the areas traditionally covered in breeding bird surveys. Additionally, sea ducks tend to nest in lower densities and initiate breeding later in the season than the dabbling and diving duck species for which our current monitoring regimes were designed. Finally, in the Pacific Flyway, sea ducks rarely appear in hunter bags (Bartonek 1994), which results in sparse data for evaluating trends in population age structure and recruitment using programs like the Migratory Bird Harvest Wing Bee.

One alternative for indexing recruitment by sea ducks is the use of age ratios calculated from direct visual counts on non-breeding areas. This technique relies upon differences in plumage appearance between adults and young to distinguish cohorts and evaluate the demographic structure of populations. Unique sub-adult plumages have been described for males of several North American sea duck species (Palmer 1976, Bellrose 1980), and recent studies have used these differences to calculate sex and age ratios on specific wintering grounds (Duncan and Marquiss 1993, Rosenberg and Petrula 1998, Smith *et al.* 2001, Mittelhauser *et al.* 2002, Rodway *et al.* 2003, Iverson *et al.* 2004). Preliminary efforts are underway to incorporate these data into population models (Robertson *in press*), and the approach appears to have considerable potential as a management tool.

The objective of this study was to expand upon previous research and use mid-winter survey data to assess the sex and age structure of sea duck populations in the Strait of Georgia, British Columbia. We focused on the nine most common species: Black Scoters (*Melanitta*

nigra), Surf Scoters (*M. perspicillata*), White-winged Scoters (*M. fusca*), Harlequin Ducks (*Histrionicus histrionicus*), Barrow's Goldeneye (*Bucephala islandica*), Common Goldeneye (*B. clangula*), Bufflehead (*B. albeola*), Common Mergansers (*Mergus merganser*), and Red-breasted Mergansers (*M. serrator*). We used shore-based counts to derive sex and (when possible) age ratio estimates. Specifically, our objectives were to (1) quantify species densities, (2) determine sex and age ratios, (3) evaluate potential patterns of sex or age-related habitat segregation that might bias estimates, and (4) make recommendations as to as the utility of multiple species winter sex and age ratio surveys as an evaluation and monitoring tool.

2 METHODS

2.1 Study area

The sheltered marine waters of the Strait of Georgia (49.5°N, 123.5°W) are home to regionally and globally significant populations of waterbird species, including sea ducks (Butler and Vermeer 1989, Campbell *et al.* 1990). The area also has experienced burgeoning human population growth during the past 100 years, creating numerous challenges for wildlife populations. Habitats available to sea ducks in the Strait of Georgia range from rich estuaries around Baynes Sound and the Fraser River Delta to rocky fjord-like shorelines along the Sunshine Coast. Some areas, such as Burrard Inlet have highly industrialized foreshores, while others, such as the Discovery Islands at the northern end of the Strait, remain largely undeveloped. The survey locations described in this report encompass the full range of habitats available to sea ducks in the Strait.

2.2 Survey timing and coverage

Mid-winter surveys were conducted during February 2003 and 2004. The surveys were timed for mid-winter because that is the period of time when age-related plumage differences are most distinct (Smith *et al.* 1998, Iverson *et al.* 2003) and distributions of wintering birds are most stable (Rodway *et al.* 2003, D. Esler and S. Boyd *unpublished data*). During 2003, counts were made at 49 sampling locations, each encompassing a 1-km shoreline transect. Based on preliminary analyses, 13 additional 1-km survey transects were added in 2004 to increase statistical power. The survey transects were grouped into eight different geographic regions within the Strait of Georgia: (1) Boundary Bay/Fraser Delta, (2) Burrard Inlet/English Bay, (3) Southern Sunshine Coast, (4) Northern Sunshine Coast, (5) Discovery Islands, (6) Campbell River/Comox, (7) Baynes Sound/Hornby Island and (8) Deep Bay/French Creek. The selection of survey transects was based on prior experience by the research team, with emphasis placed

on sites known to contain a high density of at least one target species. Appendix 1 provides the latitude and longitude of start and end points for each transect, as well as driving directions and physical descriptions of each site.

2.3 Survey protocol

All survey counts were conducted from shore by experienced observers using a spotting scope and binoculars. Data were collected only during daylight hours (08:00-16:30), when Beaufort scale sea conditions rated as 3 (small scattered whitecaps, gentle breeze, wind speed 12-19 knots) or less. Observers walked the length of each 1-km transect counting all sea ducks within 500 m of shore. Sex (M = male; F = female) and male age class (ADU = adult, ≥12 months old; 1Y = first-year, < 12 months old) class was recorded for five species for which previous research has indicated such determinations were possible: Black Scoters, Surf Scoters, Harlequin Ducks, Barrow's Goldeneye, and Common Goldeneye. For the remaining four target species—White-winged Scoters, Bufflehead, Red-breasted Merganser, and Common Merganser—first year males are difficult to distinguish from females without having specimens in hand, therefore individuals were categorized only as adult male (M_{ADU}) or other (F_{ADU}, F_{1Y}, M_{1Y}). Identification of the plumage characteristics that distinguish sex and age cohorts requires training. Manuscripts by Smith *et al.* (1998) and Iverson *et al.* (2003), which detail the plumage differences for Harlequin Ducks and Surf Scoters, respectively, should be consulted by those interested in implementing similar surveys. Photographic records of Black Scoters, Surf Scoters, Barrow's Goldeneye, and Common Goldeneye also were used, which may be obtained by contacting the authors.

In large flocks (>50 individuals) sex and age determinations often could not be made for every individual due to birds being underwater or obstructed from view by other birds. For these flocks a preliminary scan was made to estimate the total abundance of each species, followed by a secondary scan to determine age and sex composition on a species by species basis. The secondary scan proceeded slowly over flocks and was timed to occur when a minimum of birds were in motion or diving.

2.4 Data analysis and interpretation

2.4.1 Sample sizes and linear densities

For each species, the number of birds encountered was totalled according to shoreline transect. Appendix 2 contains the raw data tabulated in this format. Each block was approximately 1-km in length, which allowed conversion of abundance estimates into linear densities (birds km^{-1}). Annual comparisons were made using linear densities because the

number of transects surveyed was increased during the second year of the study. The maximum number of individuals observed per transect and the percentage of transects that were occupied by at least one bird also were estimated. Mean densities are presented ± 1 SE.

2.4.2 Sex and age ratios

The ratio of adult males to total birds (M_{ADU}:Total) was estimated for all nine target species. For Black Scoters, Surf Scoters, Harlequin Ducks, Barrow's Goldeneye, and Common Goldeneye male age ratios (M_{1Y} :M_{TOTAL}) and population sex ratios (M_{TOTAL}:F_{TOTAL}) also were calculated. Because recruitment among waterfowl is commonly indexed as the ratio of fledgling females to adult females (Cowardin and Blohm 1992) F_{1Y} to F_{ADU} ratios also were calculated. In order to do so, we assumed a 1:1 ratio between first-year males and first-year females [F_{1Y}:F_{ADU} = M_{1Y}:(F_{TOTAL} - M_{1Y})]. It should be noted that the age of first breeding for sea ducks is thought to be ≥2 years of age; hence this estimate of female age ratio is an underestimate of the actual ratio of 1Y to adult breeding females. Mean sex and age ratios are presented ± 1 SE.

Annual variation in sex and age ratios was assessed using generalized linear model ANOVA. Separate analyses were performed for each species. The models employed a binomial error distribution, treating sex and age class as binary response variables, and used a logit link function to bound parameter estimates between 0-1. The Wald test statistic (*W*) was used to judge statistical significance at the $\alpha = 0.05$ level. For Surf Scoters, three additional years of data published by Iverson *et al.* (2004), were included in the analysis in order to examine longer-term patterns in sex and age ratio variation (2000-2004). The historical data for Surf Scoters were collected using point counts at 36-57 sample locations in the Strait of Georgia from 2000-2002, most of which were included within transects covered in this study. For Harlequin Ducks, previous survey data published by Smith *et al.* (2001) for winters 1995-1999 and by Rodway *et al.* (2003) for 2000 were included. These data allowed a 10-year pattern in sex and age ratios to be investigated for Harlequin Ducks. The historical survey data for Harlequin Ducks relied primarily on transect counts, and covered many of the same areas as the present study.

2.4.3 Habitat-related variation in sea duck densities and sex/age composition

Sex and age ratio estimates derived from direct field counts are subject to bias if cohorts segregate according to habitat type. While large samples drawn from an extensive area covering all available habitats can alleviate such concerns, we felt it was important to quantify the magnitude of any distributional biases. To conduct our analyses we related geo-referenced survey data to habitat attributes described in the British Columbia Marine Ecosystem Classification (BCMEC) for the Pacific Coast of Canada (Zacharias *et al.* 1998). Specifically, we

assessed variations in sea duck densities, sex ratios, and age ratios with respect to: 1) substrate type (as categorized by BCMEC using Geological Survey of Canada sediment distribution maps), with sites classified as *hard*: bedrock, boulders, or cobble, with gravel/sand interspersed; *sand*: sand or sand/gravel; or *mud*: mud or sand/mud; 2) wind and wave exposure, categorized as *low*: protected area, fetch <50 km; or *moderate*: open sound or strait, fetch 50-500 km; and 3) depth profile (derived from bathymetric spot soundings developed by the Canadian Hydrographic Service), with classifications for *shallow*: <20 m, *photic* 20-50 m, or *mid-depth* 50-100 m.

Our statistical approach was to use Akaike's Information Criterion (AIC) to select the most parsimonious model or models among a set designed to evaluate the aforementioned relationships (Burnham and Anderson 2002). In the most fully parameterized model used in each analysis, substrate type, exposure, and depth were all included as potential explanatory variables. Less parameterized models, which considered all possible combinations of these variables (treated as main effects) were evaluated, as was a null model, for a total of 8 models in each candidate set (Table 2.4.3). Generalized linear models were used to calculate likelihood ratios for our AIC analyses, with a normal error distribution used for models predicting sea duck densities and a binomial error distribution when investigating sex and age ratios. To elucidate our results, we present ΔAIC_c and ω_i values, where ΔAIC_c is a sample-size corrected estimate of the difference in model fit between the current model and the best supported model, and ω_i is the weight of a given model, calculated as its likelihood relative to all of the models tested (Burnham and Anderson 2002). Potential explanatory variables could appear in multiple models; therefore, we made an additional calculation for $\Sigma\omega_i$ for each variable. For example, $\Sigma\omega_{substrate}$ would be the summed total of Akaike weights for the 4 models [(a) SUB, EXP, DEP; (b) SUB, EXP; (c) SUB, DEP; (d) SUB] considering substrate as a potential predictor of male age ratio for a given species. $\Sigma\ \omega_i$ values were useful for quantifying the amount of support for each variable when several models had low ΔAIC_c scores.

Table 2.4.3. Variables considered in models relating sea duck densities, sex ratios, and age ratios to habitat variables.

Model Notation	Predictor variables considered	K[†]
SUB, EXP, DEP	Substrate, Exposure, Depth	7
SUB, EXP	Substrate, Exposure	5
SUB, DEP	Substrate, Depth	6
EXP, DEP	Exposure, Depth	5
SUB	Substrate	4
EXP	Exposure	3
DEP	Depth	4
Null	None	2

[†]Number of parameters in the model.

3 RESULTS

3.1 Sea duck densities

Surf and White-winged Scoters were the two most numerous species in our survey transects, with a minimum of 1500 individuals observed per species per year (Table 3.1). The largest abundance estimate for a single species within any survey transect was for White-winged Scoters in Semiahmoo Bay, where 620 birds were observed on February 4, 2003. The maximum count for Surf Scoters occurred on the same day, in the same location, with 490 Surf Scoters observed. Black Scoters numbers also were relatively high in our survey transects, with >750 individuals counted each year and a linear density estimate of 14.4 ± 1.3 birds km^{-1}. Approximately 90% of all survey transects contained at least one Surf Scoter, while 60% had at least one White-winged Scoter and 54% at least one Black Scoter (Table 3.1).

Harlequin Duck linear densities were the third highest among the nine target species. Annual counts ranged from 1009 to 1287 birds, with approximately 79% of transects occupied by at least one Harlequin Duck, and the maximum count in of 111 any 1-km block (Table 3.1).

Annual counts ranged from 883-895 for Bufflehead, 387-413 for Barrow's Goldeneye, and 618-632 for Common Goldeneye. The proportion of transects occupied followed a similar pattern as overall densities for the Bucephala species, with approximately 95% of survey transects having at least one Bufflehead present, 83% at least one Common Goldeneye, and 43% at least one Barrow's Goldeneye (Table 3.1).

Table 3.1. Linear densities (birds km^{-1}), maximum numbers, and percentage of transects occupied for sea duck species†.

Species	Birds km^{-1} ± SE	Maximum	% transects occupied
Scoters			
Black Scoter	14.4 ± 1.3	165	53.8
Surf Scoter	36.5 ± 10.5	490	89.5
White-winged Scoter	36.9 ± 0.8	620	59.9
Harlequin Duck			
Harlequin Duck	20.7 ± 0.1	111	79.1
Bufflehead and Goldeneye			
Barrow's Goldeneye	7.3 ± 1.1	88	43.2
Bufflehead	16.2 ± 1.8	73	94.7
Common Goldeneye	11.4± 1.2	70	83.0
Mergansers			
Common Merganser	0.9 ± 0.1	26	25.5
Red-breasted Merganser	4.5 ± 0.5	34	69.7

†Linear densities and the percentage of transects occupied were averaged across years. 49 1-km blocks were surveyed in 2003 and 62 1-km blocks in 2004.

Red-breasted Mergansers counts ranged from 241-247 per year, with individuals exhibiting a highly dispersed distribution pattern. Approximately 70% of transects were occupied by at least one individual. In contrast, Common Merganser were low, averaging approximately 50 birds per year and 26% transect occupancy. Four Hooded Mergansers were observed in our survey transects during 2004, none were observed in 2003.

3.2 Sex and age ratios

3.2.1 Scoters

Black and Surf Scoter populations were the most heavily male-biased of the sea duck species surveyed (Table 3.2.1). Overall, males outnumbered females 3.4 to 1 among Black Scoters and 2.3 to 1 among Surf Scoters. The proportion of individuals that were adult male was identical for the two species, with the ratio of M_{ADU}:(M_{TOTAL} + F_{TOTAL}) estimated as 0.64 ± 0.02 for Black Scoters and 0.64 ± 0.04 for Surf Scoters. Black Scoter flocks had a higher proportion of first year males than did Surf Scoter flocks, with M_{1Y}:M_{TOTAL} ratios estimated as 0.14 ± 0.03 and 0.07 ± 0.02, respectively. Assuming a 1:1 ratio between 1Y males and females in the Strait of Georgia, female age ratios (M_{1Y} / (F_{TOTAL} - M_{1Y})) of 0.48 and 0.17 would be estimated for Black and Surf Scoters, respectively. The large difference in this last ratio when compared to the 1Y male to total male ratio indicates that these estimates are highly sensitive to small differences in 1Y male estimates.

Table 3.2.1. Sex and age ratio estimates for scoters in the Strait of Georgia during winter 2003 and 2004.

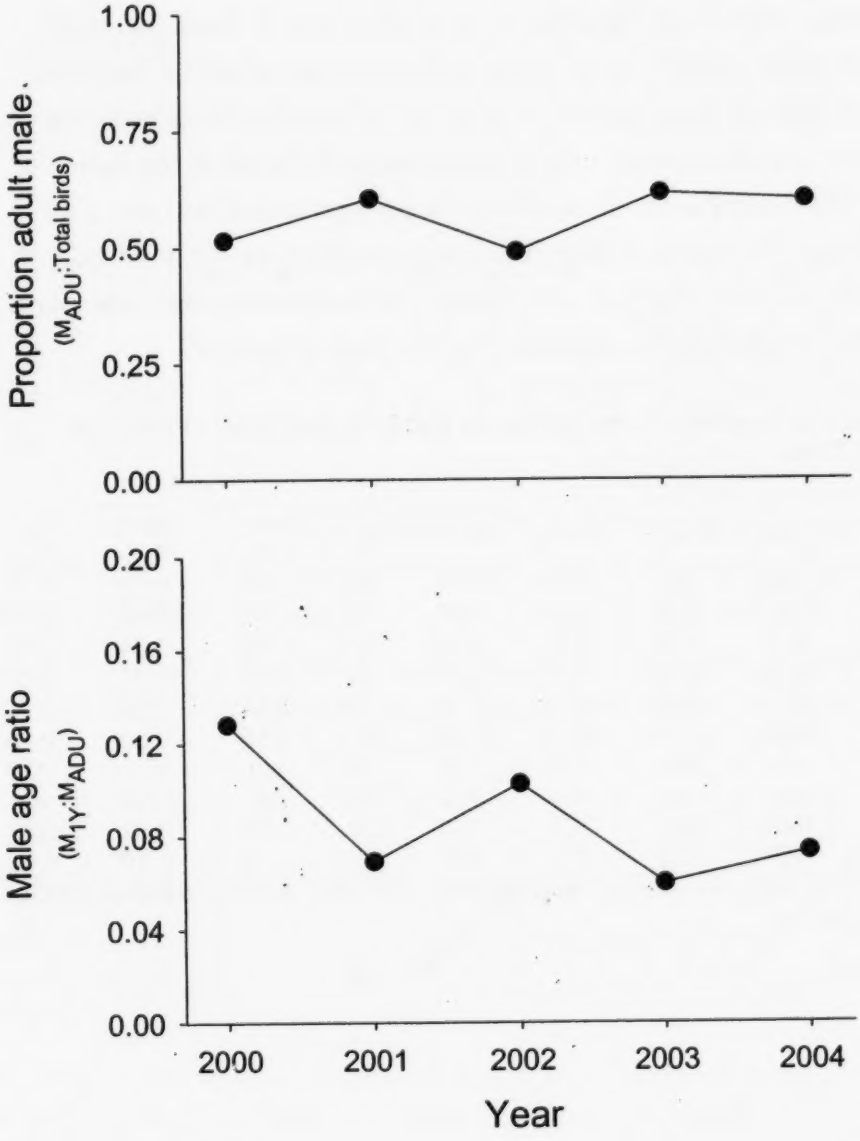
Species	Year	Total	F_{TOTAL}	M_{TOTAL}	M_{ADU}	M_{1Y}	M_{ADU}: Total	M_{1Y}: M_{ADU}	F_{1Y}: F_{ADU}
Black Scoter	2003	719	197	522	446	76	0.62	0.17	0.63
	2004	811	223	588	531	57	0.65	0.11	0.34
Surf Scoter	2000†	1221	442	779	680	100	0.56	0.15	0.29
	2001†	1316	422	894	833	62	0.63	0.07	0.17
	2002†	1212	379	833	629	72	0.52	0.11	0.23
	2003	2009	639	1370	1288	82	0.64	0.06	0.15
	2004	1613	512	1101	1020	81	0.63	0.08	0.19
White-winged Scoter	2003	1848	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	2004	2235	n/a	n/a	1180	n/a	0.53	n/a	n/a

†Data published by Iverson *et al.* (2004) for surveys conducted from 2000-2002 in the Strait of Georgia.

White-winged Scoter populations were much less adult male-biased than were Black or Surf Scoter populations. In 2004, the only year for which sex ratio data were collected, the proportion of White-winged Scoters that were adult male was 0.53 (Table 3.2.1).

Annual variation in sex ratios was not statistically significant for Black Scoters during the two years of study ($W = 2.0$, d.f. = 1, $P = 0.16$), however, variation in age ratios was significant ($W = 6.1$ d.f. = 1, $P = 0.01$). For Surf Scoters, we incorporated previously published data (Iverson *et al.* 2004) in our analyses of annual variation in sex and age ratios. Annual estimates for proportion adult male ranged from 0.49-0.62, while male age ratios ranged from 0.06-0.13. Generalized linear model ANOVA results indicated both of these differences were statistically significant (sex: $W = 22.4$, d.f. = 4, $P < 0.001$; male age: $W = 31.2$, d.f. = 4, $P < 0.001$). Figure 3.2.1 depicts the five year patterns in sex and age composition for Surf Scoter flocks in the Strait of Georgia.

Figure 3.2.1. Annual variations in sex and male age ratios for Surf Scoters wintering in the Strait of Georgia. The figure includes data collected by Iverson *et al.* (2004) during winters 2000-2002.



3.2.2 *Harlequin Duck*

Harlequin Duck populations also were male-biased. The overall sex ratio was 1.4 males per female and the proportion adult male was 0.53 ± 0.01 for the two years of survey data combined. The ratio of first year to adult males ranged from 0.07 to 0.10. Assuming a 1:1 sex ratio among immature birds, a female age ratio (M_{1Y} / (F_{TOTAL} - M_{1Y})) of 0.11:1 was calculated.

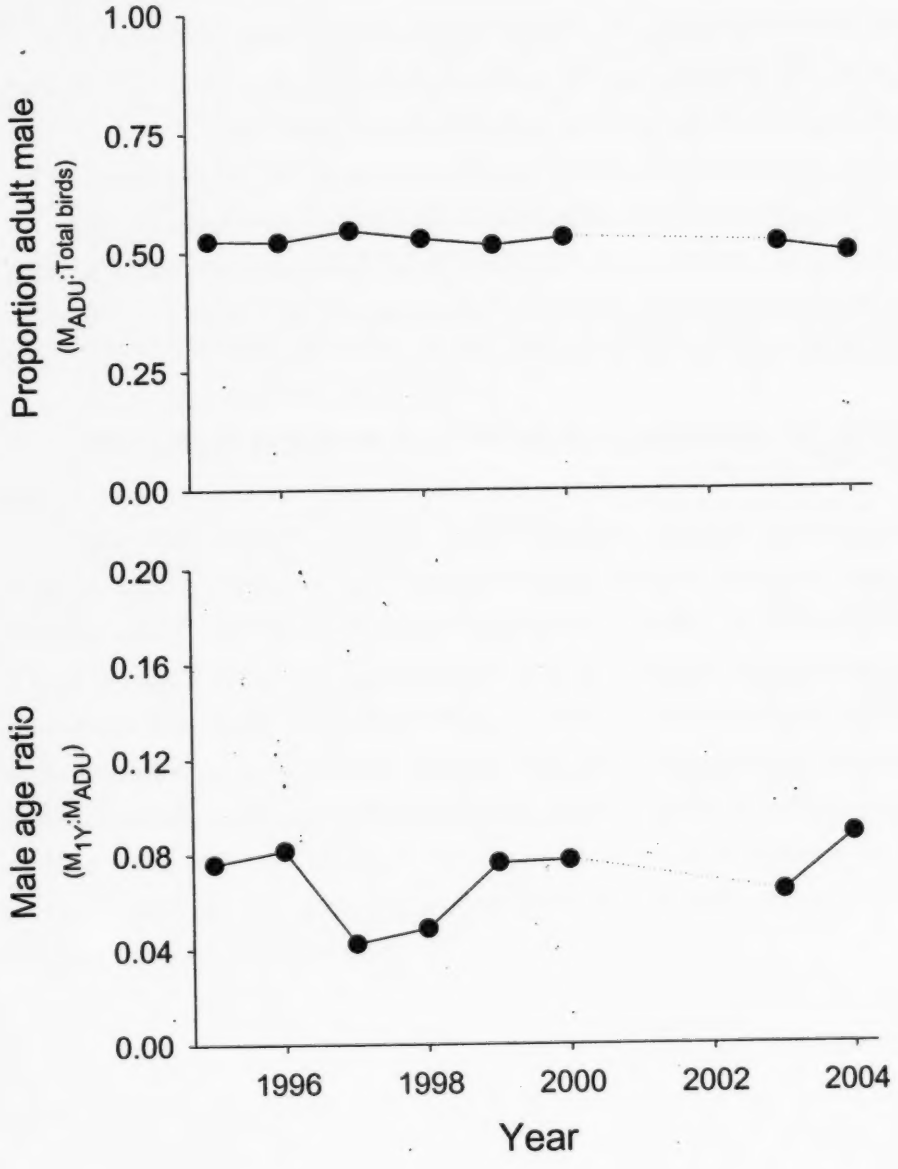
Generalized linear model ANOVA results suggested that annual variation in Harlequin Duck sex ratios was not statistically significant (W = 6.8, d.f. = 7, P = 0.45). Estimates for the proportion adult male in the population, which include data collected in this study and those reported by Smith *et al.* (2001) and Rodway *et al.* (2003), ranged from 0.52-0.56 (Table 3.2.2). Annual variation in male age ratios was statistically significant (W = 24.6, d.f. = 7, P < 0.001), with estimates ranging from 0.04-0.10 (Table 3.2.2). Figure 3.2.2 depicts a ten year pattern in sex and age composition for Harlequin Duck populations in the Strait of Georgia

Table 3.2.2. Sex and age ratio estimates for Harlequin Ducks in the Strait of Georgia during winter 2003 and 2004.

Species	Year	Total	F_{TOTAL}	M_{TOTAL}	M_{ADU}	M_{1Y}	M_{ADU}: Total	M_{1Y}: M_{ADU}	F_{1Y}: F_{ADU}
Harlequin Duck	1995†	1423	580	843	779	64	0.55	0.08	0.12
	1996†	1071	433	638	586	52	0.55	0.09	0.14
	1997†	526	219	307	294	13	0.56	0.04	0.06
	1998†	2413	1036	1377	1310	67	0.54	0.05	0.07
	1999†	4016	1682	2334	2156	178	0.54	0.08	0.12
	2000†	6825	2723	4102	3785	317	0.55	0.08	0.13
	2001	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	2002	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	2003	1009	431	578	541	37	0.54	0.07	0.09
	2004	1287	550	737	672	65	0.52	0.10	0.13

†Data published by Smith *et al.* (2001) for surveys conducted from 1995-1999 and Rodway *et al.* (2003) in 2000 in the Strait of Georgia.

Figure 3.2.2. Annual variation in sex and male age ratios for Harlequin Duck populations wintering in the Strait of Georgia. The figure includes historical data collected by Smith *et al.* (2001) and Rodway *et al.* (2003).



3.2.3 *Bufflehead and Goldeneye*

Common and Barrow's Goldeneye populations had similar adult male proportions, with overall estimates of 0.57 ± 0.03 and 0.55 ± 0.02, respectively. The proportion adult male Bufflehead was 0.50. Male age ratios were higher among Common Goldeneye than Barrow's Goldeneye, with M_{1Y}:M_{TOTAL} estimates of 0.12 ± 0.02 and 0.07 ± 0.01 in the Strait of Georgia during winter 2003 and 2004, respectively. The overall sex ratio for Common Goldeneye was 2.0:1, whereas for Barrow's Goldeneye it was 1.5:1. Female age ratios (M_{1Y} / (F_{TOTAL} - M_{1Y})) were calculated as 0.24 and 0.11 for Common and Barrow's Goldeneye, respectively.

Annual variation in Barrow's Goldeneye adult male proportions was not significant (W = 1.2, d.f. = 1, P = 0.28, Table 3.2.3), however, differences in Common Goldeneye adult male proportions were significant (W = 4.6 d.f. = 1, P = 0.03, Table 3.2.3). Variation in male age ratios was not significant for either goldeneye species (Common Goldeneye: W = 1.0, d.f. = 1, P = 0.32; Barrow's Goldeneye: W = 0.4, d.f. = 1, P = 0.50).

Table 3.2.3. Sex and age ratio estimates for Bufflehead and Goldeneye in the Strait of Georgia during winter 2003 and 2004.

Species	Year	Total	F_{TOTAL}	M_{TOTAL}	M_{ADU}	M_{1Y}	M_{ADU}: Total	M_{1Y}: M_{ADU}	F_{1Y}: F_{ADU}
Barrow's Goldeneye	2003	413	179	234	220	14	0.53	0.06	0.08
	2004	387	148	239	221	18	0.57	0.08	0.14
Bufflehead	2003	883	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	2004	895	n/a	n/a	451	n/a	0.50	n/a	n/a
Common Goldeneye	2003	618	247	365	333	32	0.54	0.10	0.15
	2004	632	200	432	378	54	0.60	0.14	0.37

3.2.4 Mergansers

The proportions adult male for Red-breasted and Common Merganser were 0.42 and 0.55, respectively (Table 3.2.4).

Table 3.2.4. Sex ratio estimates for Mergansers in the Strait of Georgia during winter 2003 and 2004.

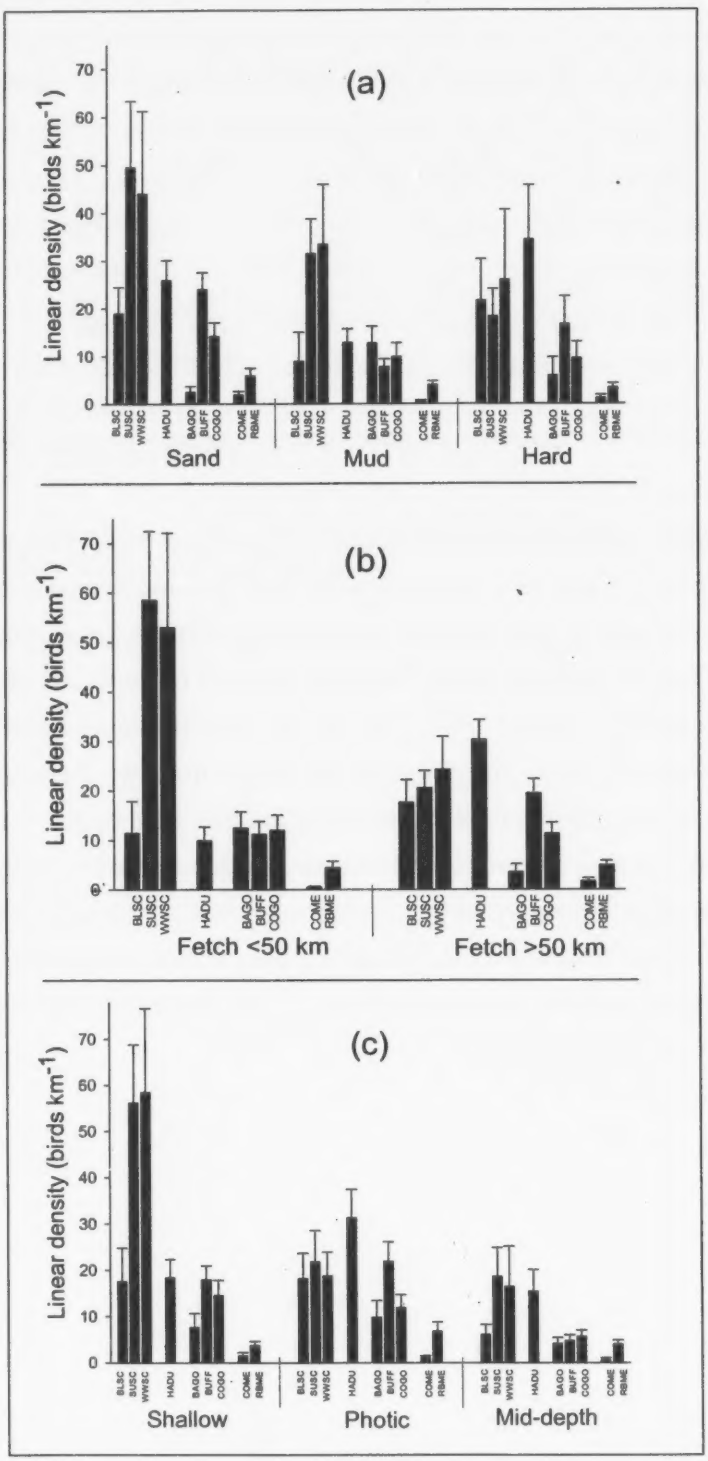
Species	Year	Total	F_{TOTAL}	M_{TOTAL}	M_{ADU}	M_{1Y}	M_{ADU}: Total
Common Merganser	2003	52	n/a	n/a	n/a	n/a	n/a
	2004	51	n/a	n/a	28	n/a	0.55
Red-breasted Merganser	2003	241	n/a	n/a	n/a	n/a	n/a
	2004	247	n/a	n/a	103	n/a	0.42

3.3 Habitat related variation in species densities and sex/age composition

3.3.1 Sea duck density

Variation was apparent in sea duck densities across habitat types. Figure 3.3.1(a-c) illustrates the relationships between sea duck linear densities and the three habitat variables we investigated. Surf and White-Winged Scoter densities tended to be higher in areas with low exposure to wind and wave and in shallower areas. Black Scoter were much less numerous than Surf and White-winged Scoters in these areas, but occurred in similar numbers to the other scoters species in more exposed transects and transects with hard substrates. Harlequin Ducks were unique among sea ducks in exhibiting their highest densities over hard bottom areas, in areas that were more exposed to wind and wave, and in areas where the maximum depth was greater. Barrow's Goldeneye densities tended to be lower in sandy bottom transects and more exposed transects, while Common Goldeneye and Bufflehead densities differed relatively little among habitat types. Merganser densities were not sufficiently high to detect habitat-specific distributional patterns in this study.

Figure 3.3.1. Linear densities of sea duck species according to (a) substrate type, (b) exposure, and (c) depth, in the Strait of Georgia.



3.3.2 *Scoters*

There was some evidence of habitat-related segregation by sex and age class among scoters. The generalized linear model best fitting the data for Black Scoter sex ratio included exposure and depth as main effects (Table 3.3.2a). This model had an Akaike weight of 0.50. There also was some support for models considering depth [(DEP): $\Delta AIC_c = 1.81$, $\omega_i = 0.20$] and the general model [(EXP, DEP, SUB): $\Delta AIC_c = 1.95$, $\omega_i = 0.19$]. $\Sigma\omega_i$ estimates for substrate, exposure, and depth were 0.27, 0.73, and 0.95, respectively. Model averaged means for Black Scoter adult male proportions tended to be highest in mid-depth and moderately exposed survey transects, and lowest in protected, photic, and sandy substrate sites (Figure 3.3.2). With respect to age-related habitat segregation, substrate appeared to be the most important predictor of male age ratio, with model averaged male age ratio estimates highest over sandy substrates (Figure 3.3.2). The model best fitting the data (DEP, SUB) had an Akaike weight of 0.49. There were two other models with $\Delta AIC_c < 2.5$, both of which included substrate as a predictor variable (Table 3.3.2a). $\Sigma\omega_i$ estimates for substrate, exposure, and depth were 0.99, 0.27, and 0.67, respectively.

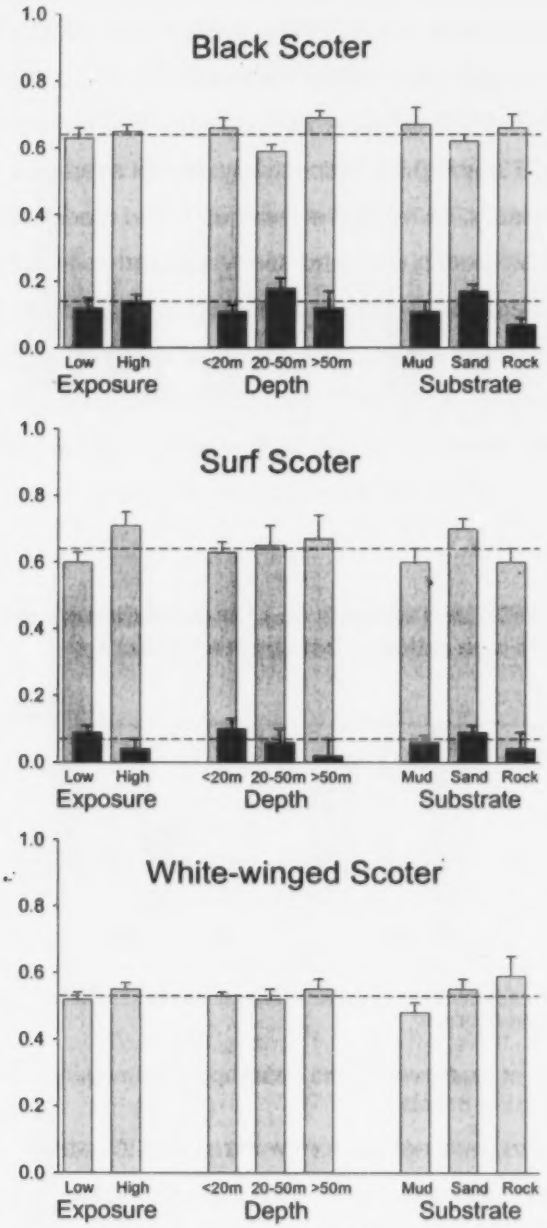
Table 3.3.2a. Akaike scores (ΔAIC_c) and weights (ω_i) for candidate models explaining variation in Black Scoter sex and age ratios according to habitat type.

Sex ratio				Age ratio			
Model[a]	K[b]	ΔAIC_c[c]	ω_i[d]	Model[a]	K[b]	ΔAIC_c[c]	ω_i[d]
EXP, DEP	5	0.00	0.50	SUB, DEP	6	0.00	0.49
DEP	4	1.81	0.20	SUB	4	1.52	0.23
SUB, EXP, DEP	7	1.95	0.19	SUB, EXP, DEP	7	2.10	0.17
SUB, DEP	6	4.69	0.05	SUB, EXP	5	3.35	0.09
SUB, EXP	5	6.08	0.02	DEP	4	9.47	0.00
Null	2	7.13	0.01	EXP, DEP	5	11.58	0.00
EXP	3	8.17	0.01	Null	2	11.46	0.00
SUB	4	8.51	0.01	EXP	3	12.94	0.00

[a] Explanatory variables in general linear models
[b] Number of estimable parameters
[c] Difference between AIC_c of the current model versus the best supported model
[d] Relative likelihood of a model among the 8 tested

Surf Scoter distributions also were not random with respect to habitat. Substrate, exposure, and depth profile all were supported as predictors of surf scoter sex ratios, with the model best fitting the data containing all three variables [(SUB, EXP, DEP): $\omega_i = 0.80$]. $\Sigma\omega_i$ estimates were 0.98, 1.00, and 0.80, for substrate, exposure, and depth, respectively. Model averaged parameter estimates for Surf Scoter adult male ratios tended to be highest over sandy substrates, in areas with higher exposure to wind and waves, and when depth profiles were deepest (Figure 3.3.2). With respect to age-related habitat segregation, two models had a high

Figure 3.3.2. Habitat-related variation in the sex and age composition of Scoter flocks. Grey bars denote ratios of adult male to total birds, black bars ratios of first year males to adult males, and dashed lines overall means.



degree of support. The best fitting included all three habitat attributes as main effects, while the next included exposure and depth and had $\Delta AIC_c = 0.49$. Akaike weights for the two models were 0.55 and 0.45, respectively (Table 3.3.2b). $\Sigma\omega_i$ estimates for the models that included substrate, exposure, and depth were 0.56, 1.00, and 1.00, respectively. Model averaged parameter estimates for Surf Scoter age ratios were highest in mid-depth, low exposure, and sandy habitats (Figure 3.3.2).

Table 3.3.2b. Akaike scores (ΔAIC_c) and weights (ω_i) for candidate models explaining variation in Surf Scoter sex and age ratios according to habitat type.

Sex ratio				Age ratio			
Model[a]	K[b]	ΔAIC_c[c]	ω_i[d]	Model[a]	K[b]	ΔAIC_c[c]	ω_i[d]
SUB, EXP, DEP	7	0.00	0.80	SUB, EXP, DEP	7	0.00	0.56
SUB, EXP	5	2.92	0.19	EXP, DEP	5	0.49	0.44
EXP	3	8.43	0.01	SUB, EXP	5	11.17	0.00
EXP, DEP	5	9.93	0.01	DEP	4	16.94	0.00
SUB, DEP	6	30.27	0.00	SUB, DEP	6	18.71	0.00
SUB	4	40.78	0.00	EXP	3	19.22	0.00
Null	2	52.02	0.00	SUB	4	36.24	0.00
DEP	4	52.16	0.00	Null	2	37.84	0.00

[a] Explanatory variables in general linear models
[b] Number of estimable parameters
[c] Difference between AIC_c of the current model versus the best supported model
[d] Relative likelihood of a model among the 8 tested

With respect to sex-related habitat associations among White-winged Scoters, several models fit the data similarly well. The models that best fit the data (SUB, DEP) had Akaike weight of 0.36, while the next best fitting models (SUB, EXP, DEP) and (SUB) had ΔAIC_c scores of 0.14 and 1.15, and $\omega_i = 0.34$ and 0.20, respectively (Table 3.3.2c). $\Sigma\omega_i$ estimates for substrate, exposure, and depth were 0.98, 0.42, and 0.70, respectively. Model averaged adult male proportions tended to be highest over hard bottom substrates, and in areas with steeper depth profiles (Figure 3.3.2).

Table 3.3.2c. Akaike scores (ΔAIC_c) and weights (ω_i) for candidate models explaining variation in White-winged Scoter sex ratios according to habitat type.

	Sex ratio		
Model[a]	K[b]	ΔAIC_c[c]	ω_i[d]
SUB, DEP	6	0.00	0.36
SUB, EXP, DEP	7	0.14	0.34
SUB	4	1.15	0.20
SUB, EXP	5	2.95	0.08
Null	2	6.33	0.02
EXP	3	10.43	0.00
DEP	4	14.14	0.00
EXP, DEP	5	14.28	0.00

[a] Explanatory variables in general linear models
[b] Number of estimable parameters
[c] Difference between AIC_c of the current model versus the best supported model.
[d] Relative likelihood of a model among the 8 tested.

3.3.3 Harlequin Ducks

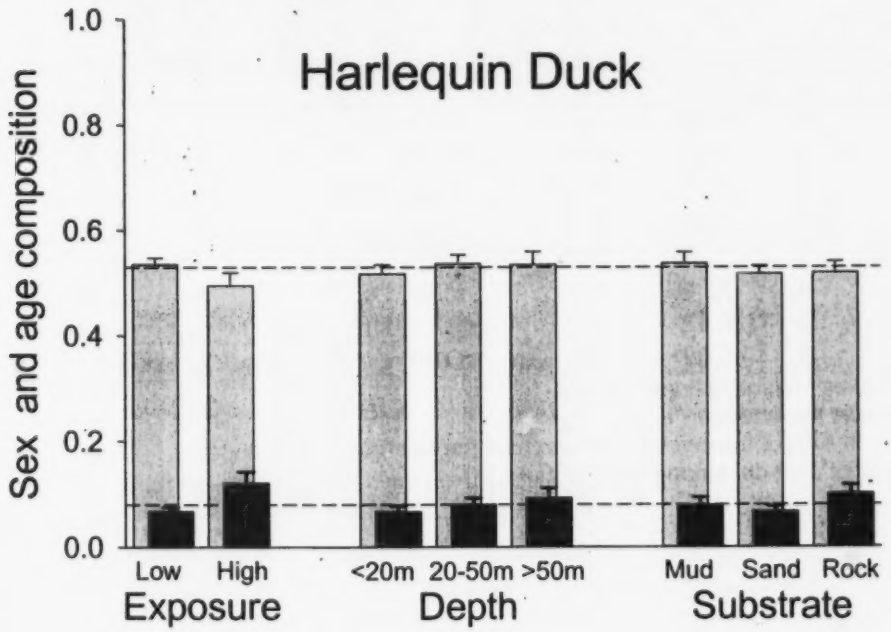
Some support was evident for exposure as a predictor of sex and age ratios of Harlequin Ducks. With respect to sex ratios, the model best fitting the data included exposure as the only main effect (Table 3.3.3). This model had an Akaike weight of 0.39. However, the null model also was well supported, with $\Delta AIC_c = 0.24$ and $\omega_i = 0.35$. $\Sigma\omega_i$ estimates for exposure, depth, and substrate were 0.52, 0.16, and 0.13, respectively. Model averaged parameter estimates for adult male proportions tended to be highest in less exposed survey transects (low: 0.55 ± 0.1 vs. moderate: 0.49 ± 0.2; Figure 3.3.3). With respect to age-related habitat segregation, exposure also was the only main effect in the model best fitting the data. This model had an Akaike weight of 0.47. Models including exposure and substrate [(EXP, SUB): $\Delta AIC_c = 1.79$, and $\omega_i = 0.19$] and exposure and depth [(EXP, DEP): $\Delta AIC_c = 1.91$, and $\omega_i = 0.18$] also received some support (Table 3.3.3). $\Sigma\omega_i$ estimates for exposure, depth, and substrate were 0.91, 0.27, and 0.30, and model averaged parameter estimates for male age ratios tended to be higher in moderately exposed areas, in rocky areas, and in areas with deeper maximum depths (Figure 3.3.3).

Table 3.3.3. Akaike scores (ΔAIC_c) and weights (ω_i) for candidate models explaining variation in Harlequin Duck sex and age ratios according to habitat type.

Sex ratio				Age ratio			
Model[a]	K[b]	ΔAIC_c[c]	ω_i[d]	Model[a]	K[b]	ΔAIC_c[c]	ω_i[d]
EXP	3	0.00	0.39	EXP	3	0.00	0.47
Null	2	0.24	0.35	SUB, EXP	5	1.79	0.19
EXP, DEP	5	3.49	0.07	EXP, DEP	5	1.91	0.18
DEP	4	3.54	0.07	SUB, EXP, DEP	7	4.02	0.06
SUB	4	3.94	0.05	Null	2	5.11	0.04
SUB, EXP	5	4.03	0.05	SUB	4	5.21	0.03
SUB, DEP	6	6.70	0.01	SUB, DEP	6	7.36	0.01
SUB, EXP, DEP	7	7.50	0.01	DEP	4	7.46	0.01

[a] Explanatory variables in general linear models
[b] Number of estimable parameters
[c] Difference between AIC_c of the current model versus the best supported model
[d] Relative likelihood of a model among the 8 tested

Figure 3.3.3. Habitat-related variation in the sex and age composition of Harlequin Duck flocks. Grey bars denote ratios of adult male to total birds, black bars ratios of first year males to adult males, and dashed lines overall means.



3.3.4 *Bufflehead and Goldeneye*

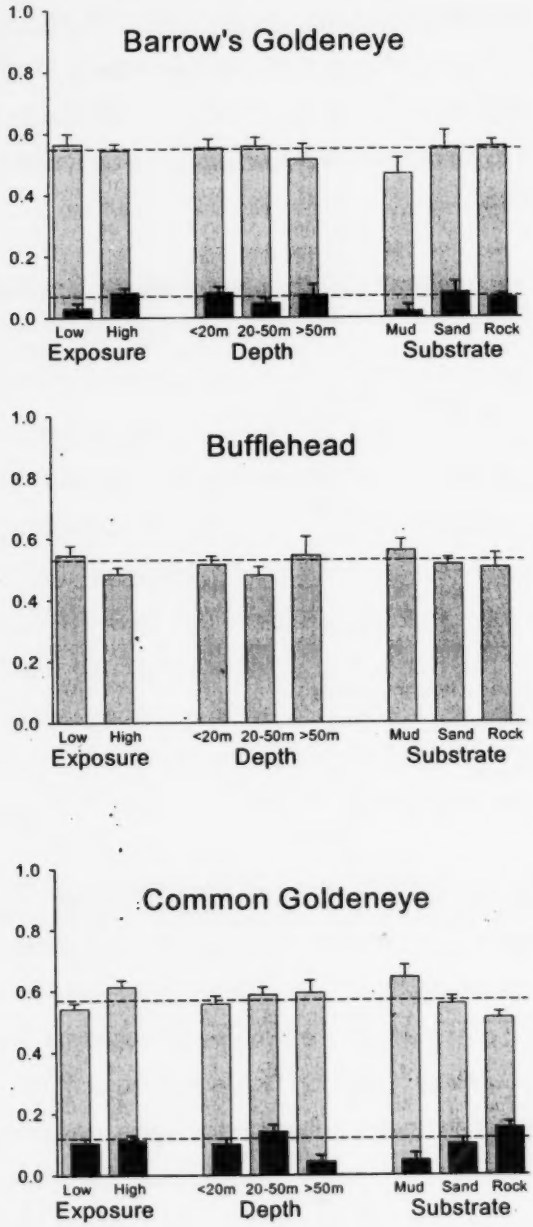
For Barrow' Goldeneye, the habitat model best fitting the data included exposure and substrate as predictors of the proportion adult male (Table 3.3.4a). This model had an Akaike weight of 0.43. There also was some support for the null model ($\Delta AIC_c = 1.45$, $\omega_i = 0.21$), and a model including substrate as a main effect [(SUB): $\Delta AIC_c = 2.170$, $\omega_i = 0.14$]. $\Sigma\omega_i$ estimates for substrate, exposure, and depth were 0.66, 0.59, and 0.13, respectively. Barrow's Goldeneye adult male proportions tended to be lowest in moderately exposed survey transects and those with muddy substrates (Figure 3.3.4). With respect to age-related habitat segregation, exposure and substrate both appeared to be important variables. The model best fitting the data [EXP] had an Akaike weight of 0.37. However, models which included substrate ([SUB]: $\Delta AIC_c = 1.80$, $\omega_i = 0.15$), substrate and exposure ([SUB, EXP]: $\Delta AIC_c = 2.14$, $\omega_i = 0.13$) and the null model ($\Delta AIC_c = 2.18$, $\omega_i = 0.13$) also received support (Table 3.3.4a). $\Sigma\omega_i$ estimates for substrate, exposure, and depth were 0.40, 0.60, and 0.22, respectively. Barrow's Goldeneye male age ratios tended to be highest in more exposed transects, and over sandy and rocky substrates (Figure 3.3.4).

Table 3.3.4a. Akaike scores (ΔAIC_c) and weights (ω_i) for candidate models explaining variation in Barrow's Goldeneye sex and age ratios according to habitat type.

Sex ratio				Age ratio			
Model[a]	K[b]	ΔAIC_c[c]	ω_i[d]	Model[a]	K[b]	ΔAIC_c[c]	ω_i[d]
EXP, SUB	5	0.00	0.43	EXP	3	0.00	0.37
NULL	2	1.45	0.21	SUB	4	1.80	0.15
SUB	4	2.17	0.14	EXP, SUB	5	2.14	0.13
EXP	3	3.26	0.08	NULL	2	2.18	0.13
EXP, DEP, SUB	7	3.77	0.07	DEP, SUB	6	3.01	0.08
DEP	4	5.06	0.03	EXP, DEP	5	3.64	0.06
DEP, SUB	6	6.12	0.02	EXP, DEP, SUB	7	4.41	0.04
EXP, DEP	5	6.67	0.02	DEP	4	4.53	0.04

[a] Explanatory variables in general linear models
[b] Number of estimable parameters
[c] Difference between AIC_c of the current model versus the best supported model
[d] Relative likelihood of a model among the 8 tested

Figure 3.3.4. Habitat-related variation in the sex and age composition of Bufflehead and Goldeneye flocks. Grey bars denote ratios of adult male to total birds, black bars ratios of first year males to adult males, and dashed lines overall means.



For Bufflehead, several models had similar fit with respect to sex-specific habitat associations. The best fitting model included exposure as a main effect and had an Akaike weight of 0.35. The null model also was supported, with $\Delta AIC_c = 0.90$ and $\omega_i = 0.22$. Model weights also were ≥ 0.10 for models considering substrate ([SUB]: $\Delta AIC_c = 1.56$, $\omega_i = 0.16$) and substrate and exposure ([SUB, EXP]: $\Delta AIC_c = 2.57$, $\omega_i = 0.10$) as main effects (Table 3.3.4b). $\Sigma\omega_i$ estimates for substrate, exposure, and depth were 0.30, 0.53, and 0.16, respectively. Model averaged adult male proportions tended to be highest over low exposure and muddy substrate transects for Bufflehead (Figure 3.3.4).

Table 3.3.4b. Akaike scores (ΔAIC_c) and weights (ω_i) for candidate models explaining variation in Bufflehead sex ratios according to habitat type.

	Sex ratio		
Model[a]	K[b]	ΔAIC_c[c]	ω_i[d]
EXP	3	0.00	0.35
Null	2	0.90	0.22
SUB	4	1.56	0.16
SUB, EXP	5	2.57	0.10
EXP, DEP	5	3.45	0.06
DEP	4	3.51	0.06
SUB, DEP	6	5.14	0.03
SUB, EXP, DEP	7	6.55	0.01

[a] Explanatory variables in general linear models
[b] Number of estimable parameters
[c] Difference between AIC_c of the current model versus the best supported model.
[d] Relative likelihood of a model among the 8 tested.

Common Goldeneye sex and age distributions also were not random with respect to habitat. With respect to sex ratios, the model best fitting the data included substrate and depth as predictors ([SUB, DEP]: $\omega_i = 0.67$). The most fully parameterized model also had some support ([SUB, EXP, DEP]: $\Delta AIC_c^c = 2.07$, $\omega_i = 0.24$). $\Sigma\omega_i$ estimates for substrate, exposure, and depth were 1.00, 0.27, and 0.90, respectively. Common Goldeneye adult male ratios tended to be highest in deep water transects, in muddy substrate transects, and in more exposed transects (Figure 3.3.4). With respect to age-related segregation, the model that included substrate and exposure had the best fit to the data ([SUB, EXP]: $\omega_i = 0.73$; Table 3.3.4c). $\Sigma\omega_i$ estimates for substrate, exposure, and depth were 1.00, 0.84, and 0.14, respectively. First-year male Common Goldeneye ratios tended to be highest in shallow and rocky transects (Figure 3.3.4)

Table 3.3.4c. Akaike scores (ΔAIC_c) and weights (ω_i) for candidate models explaining variation in Common Goldeneye sex and age ratios according to habitat type.

Sex ratio				Age ratio			
Model[a]	K[b]	ΔAIC_c[c]	ω_i[d]	Model[a]	K[b]	ΔAIC_c[c]	ω_i[d]
SUB, DEP	6	0.00	0.67	SUB, EXP	5	0.00	0.73
SUB, EXP, DEP	7	2.07	0.24	SUB	4	3.42	0.13
SUB	4	4.57	0.07	SUB, EXP, DEP	7	3.70	0.11
SUB, EXP	5	6.14	0.03	SUB, DEP	6	6.46	0.03
EXP	3	16.81	0.00	DEP	4	13.59	0.00
EXP, DEP	5	19.41	0.00	EXP, DEP	5	15.15	0.00
Null	2	21.01	0.00	Null	2	17.70	0.00
DEP	4	23.86	0.00	EXP	3	19.64	0.00

[a] Explanatory variables in general linear models
[b] Number of estimable parameters
[c] Difference between AIC_c of the current model versus the best supported model
[d] Relative likelihood of a model among the 8 tested

3.3.5 Mergansers

For Red-breasted Mergansers, the model best fitting the data indicated that exposure and depth were significant predictors of the proportion adult male ([EXP, DEP]: $\omega_i = 0.37$; Table 3.3.5). Support also was evident for the model which considered exposure as the sole main effect ([EXP]: $\Delta AIC_c = 0.94$ and $\omega_i = 0.23$). $\Sigma\omega_i$ estimates for substrate, exposure, and depth were 0.27, 0.74, and 0.52, respectively. The model averaged parameter estimates for adult male proportions tended to be higher in more exposed transects and deeper water transects. Habitat-related variation in sex ratios was not analyzed for Common Mergansers due to sample size considerations.

Table 3.3.5. Akaike scores (ΔAIC_c) and weights (ω_i) for candidate models explaining variation in Red-breasted Merganser sex ratios according to habitat type.

Sex ratio			
Model[a]	K[b]	ΔAIC_c[c]	ω_i[d]
EXP, DEP	5	0.00	0.37
EXP	3	0.94	0.23
SUB	4	2.73	0.09
Null	2	2.74	0.09
SUB, EXP, DEP	7	3.23	0.07
SUB, EXP	5	3.48	0.06
SUB, DEP	6	4.71	0.04
DEP	4	4.57	0.04

[a] Explanatory variables in general linear models
[b] Number of estimable parameters
[c] Difference between AIC_c of the current model versus the best supported model.
[d] Relative likelihood of a model among the 8 tested.

4 CONCLUSIONS

Given the lack of data available for monitoring sea duck populations, information as basic as the sex and age structure of wintering flocks is valuable for management purposes. The mid-winter surveys described in this report provide important baseline information on the density and composition, as well as the patterns of annual variation and habitat use, for a suite of species of conservation concern. Several findings are of particular interest and their biological implications and associated measurement considerations are discussed below.

The most striking finding in this study was the strength of the male-bias in adult sex ratios, particularly among Black and Surf Scoters. Adult sex ratios of most waterfowl are skewed toward males (Bellrose *et al.* 1961), and there are several different hypotheses to explain the phenomenon. The major cause is thought to be higher mortality rates experienced by females during the breeding season (Johnson *et al.* 1992, Sargeant and Raveling 1992). Hunting mortality rates also have been shown to differ between the sexes, which can influence sex ratios among adults (Johnson and Sargeant 1977). Among diving ducks, inter-sexual competition during the non-breeding season has been proposed as another mechanism whereby adult female mortality might exceed that of males. Male diving ducks tend to be behaviourally dominant to females, and in some instances exclude them from preferred feeding habitats during winter (Nichols and Haramis 1980, Owen and Dix 1986, Alexander 1987). The magnitude of the male-bias in adult sex ratios tends to be greater among diving ducks than dabbling ducks, with Canvasbacks (*Aythya valisineria*) and Common Pochards (*Aythya ferina*) providing two of the more extreme examples, exhibiting adult sex ratios of two or three males for every female in some wintering areas (Haramis *et al.* 1985, Owen and Dix 1986). Our data suggest some similarity between sea ducks and diving ducks in this regard. Among the five species for which adult sex ratios could be readily estimated, Surf and Black Scoters had the most skewed adult sex ratios, with estimates of 2.3 and 3.5 males per female respectively. Harlequin Ducks were the least skewed, with 1.4 males per female, while the two goldeneye species were intermediate, with adult sex ratios estimated as 1.5 males per female for Barrow's Goldeneye and 2.0 males per female for Common Goldeneye. For White-winged Scoters, Bufflehead, and Common Mergansers, the proportion adult male ranged from 50-55%. These proportions were similar to those estimated for the Harlequin Duck, and assuming similar age ratios, would suggest adult sex ratios of 1.3 to 1.5 males per female. Red-breasted Mergansers had a lower proportion adult male than the other eight species, with only 42% categorized as adult male by plumage appearance.

A second important finding in this study was the low proportion of immature birds. Male age ratios (M_{1Y}:M_{TOTAl}) ranged from 0.07 for Surf Scoters and Barrow's Goldeneye to 0.14 for Black Scoters. This result was not surprising, given the high adult survival-low annual productivity life history strategy characteristic of sea ducks. However, uneven sex ratios and age-structured populations have important implications when translating census data to measurements of effective population size. Taking Common Goldeneye as an example, in 2004 a total of 632 individuals were observed within our survey transects, of which 200 were female. Assuming equivalent numbers of first year males and females, an age of first breeding of 2 years, and sub-adult survival rates of ~70%, the number of females of breeding age in our mid-winter count would have been approximately:

$$\begin{aligned} N_{BreedingAgeFemale} &= N_{TotalFemales} - N_{1YFemales} - N_{2YFemales} \\ &= 200 - 54 - (0.7 * 54) \\ &= 108 \end{aligned}$$

This estimate does not account for annual variation in productivity or survival, but does illustrate the degree to which the number of potential breeding pairs can be overestimated if population sex and age structure are not taken into account. In this example, the effective population size would only be about 34% of the census count.

Given the age ratios we estimated, a natural question is to what degree do they match the expected, given the survival rates estimated for various sea duck species? In the simplest of demographic models, where the population growth rate is maintained at $\lambda = 1$ and immigration is ignored, birth and death rates must be in balance. While reliable estimates of annual survival are not available for all sea duck species, and geographic variation is likely, current estimates range from 60-90%, depending upon species, sex, age, and methodological approach (Ludwichowski *et al.* 2002, Eadie *et al.* 1995, Savard and Eadie 1989, Cooke *et al.* 2000, Kehoe *et al.* 1989). Robertson (*in press*) addressed the question of what survival rates and juvenile/adult ratios are needed to maintain stable populations for Harlequin Ducks using a matrix-based age-structured population model, and concluded that there is a significant mismatch between recruitment, as estimated using winter age ratios, and survival. Survey data indicate that Harlequin Duck populations in the Pacific Flyway are not undergoing the declines such a mismatch would indicate (*S. Boyd, unpubl. data*), and one must question whether recruitment, survival, or both are being underestimated using existing methodologies.

There is a possibility that age ratios were underestimated using direct visual counts on wintering areas. Previous research on Harlequin Ducks showed potential for misidentification of

first year males when using boat-based rather than shore based surveys (Rodway *et al.* 2003). Rodway and coauthors also discovered a tendency for first year males to be further from shore than adult males, and used a correction factor to account for sampling bias. Many of the differences in plumage appearance that are used to distinguish cohorts are subtle, and several important considerations must be made when evaluating the ability of researchers to accurately identify them. The first pertains to moult timing. When newly fledged male sea ducks first arrive on non-breeding areas they exhibit cryptic plumages that are very similar to those of adult females. The timing of moult from the first basic into the first alternate plumage is somewhat variable, which is why our survey was timed for late January-early February—the period when plumage differences were shown to be most pronounced for Surf Scoters (Iverson *et al.* 2003). However, we can not eliminate the possibility that some portion of early moulting first year males progress to the point where they are indistinguishable from adult males, or that some late moulting birds are indistinguishable from females, using field observations alone. When birds are in hand, the differences are clear (e.g. Smith *et al.* 2001, Iverson *et al.* 2003), however, at a distance of 100 m through a spotting scope, traits such as belly and body plumage coloration, the presence or absence of facial markings, and bill coloration and shape are more difficult to diagnose with certainty. As yet, a methodology for determining the proportion of misidentified birds has not been developed. Finally, it should be noted that some confusion was encountered in our survey with respect to bill coloration among Black Scoters. Originally, it was assumed that females had no yellow coloration on their bills, however subsequent evaluation of birds captured in a telemetry study showed that adult females (>2Y) often have yellow areas on the top of their bills. One of the primary means of identifying first year male Black Scoters was the existence of a bulbous yellow enlargements similar to those of adult males, and it is likely that some females were classified as first year males when other diagnostic traits such as breast and belly coloration and the presence of black and brown mottled body feathers were not seen.

For the species we investigated, some segregation of the sex and age classes among habitats was apparent. However, the magnitude of distribution biases was generally quite small. The most pronounced effects were evident for Surf Scoters—where adult male proportions tended to be higher in transects with sandy substrates and those with higher exposure to wind and waves, and male age ratios tended to be higher in transects of shallower depth and those with lower exposure to wind and wave; Black Scoters—where adult male proportions were highest in more exposed transects; Harlequin Ducks—where male age ratios were highest in more exposed sites; and Common Goldeneye—where adult male proportions were highest in exposed transects. While habitat-related variation was minimal, and sampling bias could be

minimized by ensuring large samples are collected representatively from available habitats, some larger distributional considerations remain. For species such as Black Scoters, Surf Scoters, and Common Goldeneye, for which sex-ratios were heavily male-biased, and Red-breasted Mergansers, for which females outnumbered males; the possibility that the sexes are geographically segregated must be considered. Such patterns are not uncommon among migratory bird species (Ketterson and Nolan 1976; Cristol *et al.* 1999), and the ecological implications include differential exposure to selective pressures, such as inclement weather or predation. Pairing chronology and the durability of pair bonds also may be affected, which in turn influences gene flow and population structure (Cooke *et al.* 2000). With respect to age-related differences in non-breeding distribution an important question arises with respect to defining population units. If immature birds do not winter in the same locations as their parents, then considerable complexity is added when attempting to use winter age ratios as an index of recruitment. The spatial scale at which populations would have to be monitored would become prohibitively large, and the power of inference at smaller spatial scales, like the Strait of Georgia would be limited.

Data on the sex and age composition of sea duck populations in different wintering areas is extremely sparse. Iverson *et al.* (2004) used a volunteer survey to investigate latitudinal patterns in sex and age ratios in the Pacific Flyway and found no evidence that larger numbers of females wintered in more southerly areas. However, sample sizes were small, and recent studies initiated in Baja, Mexico, suggest sex ratios may be closer to 1:1 (D. Rizzolo and T. Bowman personal comment). With respect to pairing chronology, waterfowl that pair late tend to exhibit greater segregation of the sexes and more disparate sex ratios during the non-breeding season compared to species that pair early (Hepp and Hair 1984). Among the species we investigated, Harlequin Ducks are the best studied in this regard. Harlequin Duck pairing occurs early, with >50% of females being paired by December (Robertson *et al.* 1998). Moreover, it is common for females to reunite with the same male, with the repairing rate approaching 100% if both partners are known to have survived and returned to the same wintering ground (Gowans *et al.* 1997, Robertson *et al.* 1998). There is some evidence for early pairing among Barrow's Goldeneye, particularly among previously paired birds (Savard 1985). In contrast, Kahlert *et al.* (1998) found that male and female Red-breasted Mergansers remain segregated for most of the winter, with pairs only beginning to separate from flocks in early spring. Among the other sea duck species, the chronology of pair formation is less certain. Brown and Fredrickson (1997) suggested that because White-winged Scoters are among the latest migrating and nesting waterfowl, pairing during migration seems likely. Our own observations during winter in the

Strait of Georgia, however, suggest that a high proportion of adult females behave as if paired during early winter. White-winged Scoters tend to form loose flocks during early winter, with male-female pairs moving in close proximity, diving synchronously, and males defending a buffer space around their presumed mate. In contrast, Black and Surf Scoters typically form larger, denser flocks, within which it impossible to recognize pairs with any certainty. Courtship activities occur all winter, but intensify during spring migration.

There is a clear need for new techniques to monitor the health of sea duck populations. Traditional methods have not worked well for most species because they breed in low densities in remote portions of the continent. The primary conservation implication of our study is that winter sex and age ratio surveys can be a reliable, inexpensive means of gathering data for an important demographic index. However, several important considerations must be made before incorporating such data in population models. These include: 1) ensuring that age ratios are not underestimated, owing to the difficulty of visually distinguishing sex and age cohorts; 2) determining the validity of using male age ratios to infer female age ratios and ensuring that composition estimates are representative of the population as a whole, and 3) determining the spatial scale at which true populations are being studied, in order to ensure that inference about the survival and recruitment are valid. To answer these questions, further study is required. However, such an effort appears warranted to better equip us to understand declining sea duck populations and manage them for sustainability.

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7 APPENDICES

7.1 Appendix 1: Survey transect locations

Transect Code	Transect Name	Access	BCME Classification	Starting point		Ending point	
			Sub Exp Dep	Lat Long Magnetic bearing	Description	Lat Long Magnetic bearing	Description
BBFD-1	White Rock South	Highway 99S to Peace Arch Prov. Park, follow Beach Rd west, then north, park at Canadian Legion Hall--walk RR tracks	Sand Low <20m	49.0082 -122.7666 195	Mile marker 120	49.0130 -122.7786 195	N end of railway bridge
BBFD-2	White Rock Jetty	Marine drive to White Rock waterfront, public jetty is near midpoint of transect	Sand Low <20m	49.0180 -122.7956 195	Small ramp leading to beach ~700 m S of jetty	49.0218 -122.8080 195	~20 m N of White Rock museum
BBFD-3	1001 Steps South	Crescent Rd. to 128th, L on 128th, R on 16th, R on 126A. Park at corner of 15A and 126A and take steps down to RR tracks	Mud Low <20m	49.0245 -122.8649 170	P-20/F-20 sign on RR tracks, just S of point	49.0323 -122.8755 195	Bridge where trail meets RR tracks, at mile post 125.6
BBFD-4	1001 Steps North	Adjacent to BBFD-3	Mud Low <20m	49.0323 -122.8755 195	Bridge where trail meets RR tracks, at mile post 125.6	49.0401 -122.8820 230	~40 m beyond RR light set
BBFD-5	Tsawwassen Ferry	Pullout on north side of highway 17 turnpike, which leads to ferry terminal; transect is approximately 1/2 km before toll windows at entrance	Sand Low <20m	49.0191 -123.1127 not recorded	At lane selection sign which passes over highway	49.0119 -123.1229 not recorded	1 km W of lane selection sign
BBFD-6	Iona South	Turn off main road to airport on Templeton St, following sign to MacDonald Beach park, pass park and continue on Ferguson Rd past sewage treatment plant. Park near end of Iona jetty--transects are at far end of jetty	Sand Low <20m	49.2056 -123.2639 not recorded	End of Iona jetty, looking South	49.2083 -123.2506 not recorded	1 km from end of jetty at 3km painted marker
BBFD-7	Iona North	Adjacent to BBFD-6	Sand Low <20m	49.2056 -123.2639 not recorded	End of Iona Jetty, looking North	49.2083 -123.2506 not recorded	1 km from end of jetty at 3km painted marker

Transect Code	Transect Name	Access	BCME Classification	Starting point		Ending point	
			Sub Exp Dep	Lat Long Magnetic bearing	Description	Lat Long Magnetic bearing	Description
BIEB-1	Spanish Banks	NW Marine Dr. to Spanish Banks Beach (west end of transect is where road begins to climb hill toward UBC)	Mud Low <20m	49.2787 -123.2276 350	Boulder outcrop, W end of beach where distance to bluffs narrows	49.2772 -123.2133 350	Boulder outcrop W of Jericho pier
BIEB-2	Kitsilano Beach	4th Ave Vancouver, access is along seawall	Mud Low <20m	49.2741 -123.1616 345	At west end of seawall path, in front of an interpretive sign, 50 m W of sailing club pier	49.2776 -123.1509 345	Just beyond point, bearing is across to 2 navigation buoys
BIEB-3	English Bay	Beach Ave, Vancouver, access is along seawall	Mud Low <20m	49.2865 -123.1428 215	Roof of concession stand, midway along beach	49.2939 -123.1499 255	South end of 2nd beach
BIEB-4	Third Beach	Stanley Park, Vancouver, access is along seawall	Mud Low <20m	49.3045 -123.1561 245	N end of 3rd beach, at pull-out w/ 6 benches	49.2967 -123.1534 235	South end of 2nd beach
BIEB-5	Siwash Rock	Stanley Park, Vancouver, access is along seawall	Mud Low <20m	49.3124 -123.1503 310	5.5 km marker, ~100 m E of point leading into the first narrows	49.3045 -123.1561 245	N end of 3rd beach, at pull-out w/ 6 benches
BIEB-6	Lions Gate	Stanley Park, Vancouver, access is along seawall, beneath Lions Gate Bridge	Mud Low 20-50m	49.3063 -123.1334 30	Pipeline crossing sign	49.3142 -123.1415 355	Prospect Point light
BIEB-7	Ambleside	W of Lions Gate bridge, N shore of Burrard Inlet	Mud Low <20m	49.3215 -123.1416 155	W bank of Capilano River, looking across to Prospect Point	49.3257 -123.1546 175	Wooden pier
BSHI-1	Goose Spit	Drive through Comox on Comox Ave, left on Pritchard, right on Balmoral, straight at 4 way stop, over hill to Goose Spit	Mud Low <20m	49.6640 -124.9153 302	Inside spit, on point of land next to dock, next to white shed, look across to blue house on opposite shore	49.6655 -124.9017 282	First pullout inside of spit between 2 concrete picnic tables

Transect Code	Transect Name	Access	BCME Classification	Starting point		Ending point	
			Sub Exp Dep	Lat Long Magnetic bearing	Description	Lat Long Magnetic bearing	Description
BSHI-2	Ships Point	Highway 19A to Ships Pt Rd, right on Baynes Dr., section is alongside Ships Pt. Park	Sand Low 20-50m	49.4976 -124.7926 35	Middle of rocky point on sedimentary shelve, 700 m NE of point	49.4927 -124.7940 195	~100 m from head of bay, NW of Ships Point
BSHI-3	Denman Point	Denman Island, access via Scot Road, park at L in road, walk out to Denman Point	Mud Low 20-50m	49.5540 -124.8432 230	250m S of Denman Point, 50m N of large rock at high tide line	49.5607 -124.8423 20	Point with small wooden shed on N end of cove
BSHI-4	Fillongley	Denman Island, Provincial Park	Hard Mod <20m	49.5366 -124.7556 75	570 m South of car park @ large tree root	49.5452 -124.7595 40	~250 m S of small point, before mouth of creek
BSHI-5	Whalebone Point	Denman Island, where Denman Rd and East Rd join, South of Denman-Hornby Ferry Terminal	Sand Low <20m	49.5040 -124.7312 82	Small creek on N end of Whalebone Cove	49.5111 -124.7371 25	~20 N of buried Cable Sign
BSHI-6	Dunlop Point	Hornby Island--east side of island at end of Seawright Rd.	Hard Mod 20-50m	49.5126 -124.6363 5	Along bluffs between Dunlap Point and Little Tribune Bay	49.5069 -124.6366 115	On point in middle of sandpiper bay
BSHI-7	Tralee Point	Hornby Island--on north side of island access from end of Ostby Rd	Sand Mod 20-50m	49.5417 -124.6425 300	30 m W of Tralee point, in E end of Seabreeze Bay	49.5377 -124.6314 0	On broad point below small limestone bluffs
BSHI-8	Phipps Point	Hornby Island-southwest end of island, access down side road where Shingle Spit Rd turns into Central Rd.	Sand Mod 20-50m	49.5312 -124.7098 240	In bay S of Phipps Point, 500 m S of point	49.5390 -124.7092 265	At S end of broad tidal shelve, 500 m N of Phipps Pt, at fossil beds
BSHI-9	Cape Gurney	Hornby Island--Northeast end of island--access via Helliwell Rd.	Hard Mod 20-50m	49.5232 -124.5920 33	Near point at NW end of beach, access at Texada Rd	49.5295 -124.6019 320	In front of Helliwell house 150 of NW of park boundary

Transect Code	Transect Name	Access	BCME Classification	Starting point		Ending point	
			Sub Exp Dep	Lat Long Magnetic bearing	Description	Lat Long Magnetic bearing	Description
BSHI-10	Grassy Point	Hornby Island--north end of island--near Galleon beach access	Sand Mod 20-50m	49.5511 -124.6697 320	160 m W of Grassy Point (Shields Point)	49.5459 -124.6593 10	840 m E of Grassy Point (Shields Point), on Point E of Grassy Bay
BSHI-11	Hinton Road	Denman Island, SW end, access via Lacon Rd to Hinton Rd	Sand Low 20-50m	49.4851 -124.7411 180	Between 2 houses, SE one larger with partial 2nd story and decks, NW one with loft and no decks	49.4887 -124.7534 185	Just east of the 3rd small point to W of Hinton Rd beach access 430 m W of Hinton Rd beach access
BSHI-12	Gartley Point	Turn off 19A on Gartley road, access from small dirt road that goes to beach where Gartley curves N	Mud Low <20m	49.6344 -124.9222 20	In SW corner of bay NW of Kingfisher Resort and 380 m S of road access	49.6433 -124.9237 20	N most point of land before Creek outlet
CRCX-1	Point Holmes	Alongside Lazo Road where it hits the Ocean	Hard Mod <20m	49.6940 -124.8649 110	Pt Holmes, right under house on hill, 300 m S of boat ramp	49.6883 -124.8756 110	Just before houses start again ~50 m N of beaches
CRCX-2	Kin Beach	Access is just N of CFB Comox, use Kilmorely Rd.	Hard Mod <20m	49.7314 -124.9016 21	In small bay ~30 m N of point N of Kin, in front of yellow stucco house	49.7260 -124.8904 35	~100 m S of Kilmorly Rd access, in military campground
CRCX-3	Wilkinson Road	Just N of Little River ferry terminal, drive N along Wilkinson Rd to end	Sand Mod <20m	49.7477 -124.9375 20	20 m S of point ~600 m N of end of Wilkinson Road, Point S of Cloudcraft Point	49.7404 -124.9286 37	Just N of ferry terminal
CRCX-4	Kitty Coleman	Turn off island Hwy 19A on Coleman Road, then N on Left Rd, then R on Whitaker to end	Sand Mod <20m	49.7922 -125.0020 10	Just before 3rd house past N end of park, ~ 30 m S of middle house	49.7863 -124.9918 28	40-50m S of southern park boundary

Transect Code	Transect Name	Access	BCME Classification	Starting point		Ending point	
			Sub Exp Dep	Lat Long Magnetic bearing	Description	Lat Long Magnetic bearing	Description
CRCX-5	Miracle Beach	Turn off island Hwy 19Afollowing sign to Miracle Beach Prov. Park	Sand Mod <20m	49.8536 -125.0985 3	50-100 m S of river	49.8479 -125.0879 14	Nondescript shoreline E of park, in front of large house set close to beach
CRCX-6	Salmon Point	Turn off island Hwy 19A on Salmon Pt Road	Sand Mod 20-50m	49.8902 -125.1260 0	E side of entrance to marina breakwater at Salmon Point	49.8834 -125.1169 30	Forested section of park, N of Oyster River, 1 km S of Salmon Pt. Marina
CRCX-7	Oyster Bay	Parking area is adjacent to Hwy 19A	Sand Mod 20-50m	49.8958 -125.1502 350	Foot crossing on creek N of rest area	49.9001 -125.1625 30	Nondescript stretch of highway
CRCX-8	Shelter Point	Right on Heard Rd, off Hwy 19A	Sand Mod 20-50m	49.9359 -125.1870 80	Opposite Engles Rd	49.9443 -125.1882 16	N of shelter point, N of large offshore rectangular rock
CRCX-9	Willow Point	Turn off Hwy 19A Adams Rd to Adams Park	Sand Mod 20-50m	49.9742 -125.2195 40	Midway between start of bay and point to the north	49.9686 -125.2093 35	In front of 2nd house, N of public access
CRCX-10	Rotary Beach	along old Island Hwy, Start at Rotary Beach Park (S end of section)	Hard Low 20-50m	49.9948 -125.2282 70	S end of rotary beach park, at rock wall where 1st house starts	50.0035 -125.2317 60	At boat rental, just N of super 8 motel
CRCX-11	Alders	Turn off Hwy 19A in Merville	Sand Mod <20m	49.8317 -125.0561 45	In bay S of Alders Resort, 500m S of public access	49.8392 -125.0635 20	Treed section 200 m N of large steep gabled house with cement block breakers 500 m N of public access
CRCX-12	Cloudcroft	Off Hwy19A	Sand Mod <20m	49.7525 -124.9429 45	On broad point below steep slope, ~30 m N of small creek. 500 m S of Cloudcroft access	49.7598 -124.9513 0	S of broad point on S end of Seal Bay, btw 2 homes

Transect Code	Transect Name	Access	BCME Classification	Starting point		Ending point	
			Sub Exp Dep	Lat Long Magnetic bearing	Description	Lat Long Magnetic bearing	Description
DBFC-1	Mapleguard Spit	Turn of Hwy 19A on Gainsberg, Right on Burne, Left on Deep Bay Drive, Park at first pull out on right where sea is visible	Sand Mod <20m	49.4677 -124.7274 346	Second point N of parking area, 210 m N of pull out	49.4600 -124.7206 44	Looking across to Chrome Island
DBFC-2	Bowser	Turn off Hwy 19A on Bowser Rd. Access at end of Bowser Rd	Sand Mod <20m	49.4372 -124.6708 5	Small resort with 6 brown cabins, 500m N of Bowser rd, in front of 3rd cabin from north	49.4309 -124.6615 40	Just south of continuous stretch of houses, 500 m S of Bowser Rd
DBFC-3	Qualicum Bay	Access directly from hwy 19A	Sand Mod <20m	49.4050 -124.6309 4	500 m N of Henry's Kitchen, by yard with many flags	49.4025 -124.6182 350	In front of Indian Lodge
DBFC-4	Van Isle	Beach access road off 19A, adjacent to N end of Van Isle Rd	Sand Mod <20m	49.3913 -124.5971 10	100 m N of small creek, in front of wooden barn shaped house	49.3861 -124.5858 35	Along wooded section of shore, ~100 m SE of row of cement blocks in intertidal
DBFC-5	Qualicum Beach	Access directly from hwy 19A	Sand Mod <20m	49.3541 -124.4544 338	500 m N of public restrooms, 100 m from end of public walk	49.3560 -124.4410 320	Beside visitor centre
DBFC-6	Columbia Beach	From Hwy 19A turn onto Columbia Dr., left on Admiral Tyron, beach access immediately on right	Sand Mod 20-50m	49.3539 -124.3753 0	Resort w/ beige cabin and large lawn	49.3525 -124.3620 10	Just W of spit on W side of French Creek
DIIS-1	Cape Mudge	Quadra Island, south on Cape Mudge Road, right on Joyce to lighthouse Road, follow signs to Tsa-Kwa-Luten Lodge, take little road around left and down to shore by waterfront cabins	Mud Mod >50m	49.9980 -125.1953 210	~50 m SE of lighthouse, ~500 m W of lodge, in front of white house w/ red roof	49.9951 -125.1823 135	At cape below sand cliffs, 500 m east of Tsakwaluten Lodge

Transect Code	Transect Name	Access	BCME Classification	Starting point		Ending point	
			Sub Exp Dep	Lat Long Magnetic bearing	Description	Lat Long Magnetic bearing	Description
DIIS-2	Francisco Point	Quadra Island, turn off of Cape Mudge Rd onto Petroglyph Rd (to end) and walk down to shore	Mud Mod >50m	50.0165 -125.1503 10	110 m N of Petroglyph road access, 20 m S of small cabin right on shore	50.0088 -125.1495 115	Around Francisco Pt toward Cape Mudge
DIIS-3	Smiths Road	Quadra Island, turn off Heriot Bay Rd onto Smiths Rd, onto Wawki, switch back downhill, left turn at bottom of hill just before houses start	Mud Mod >50m	50.0350 -125.1703 35	500 m N of Smiths Rd. beach access	50.0398 -125.1664 70	Just S of large angular rock in intertidal zone, 500 m S of Smiths Rd
DIIS-4	Rebecca Spit West	Quadra, turn off Heriot Bay Rd onto Rebecca Spit Rd, drive into Provincial Park	Mud Mod >50m	50.0972 -125.1850 240	At narrowest part spit at the base, facing W toward pilling in water	50.1047 -125.1926 245	Just south of N end of spit
DIIS-5	Rebecca Spit East	Quadra Island, turn off Heriot Bay Rd onto Rebecca Spit Rd, drive into Provincial Park	Mud Mod >50m	50.1056 -125.1926 25	Narrow neck near N end of spit, just N of N end of DIS4 section, on east side of spit	50.0983 -125.1844 40	~50m N of narrow neck on spit that road passes. Near S end of DIIS4, but on E side of spit
DIIS-6	Yaculta	Quadra Island, village site aka Cape Mudge	Mud Mod >50m	50.0267 -125.1988 225	~300 m N of government dock, 500 m S of where road leaves water and heads uphill	50.0322 -125.2092 215	500 m N of parking spot where road leaves water and goes uphill
LOSC-1	Chaster Park	Access from Gibson via Pratt rd, then W on Gower Pt. Rd to Chaster Park	Mud Mod 20-50m	49.3893 -123.5540 170	~220 m E of Chaster Park, at E end of cleared lot	49.3972 -123.5608 170	In front of large tree
LOSC-2	Beach Ave West	Near Roberts Creek Prov Park, access via Flume Rd. then W on Beach Ave to sharp turn, park in gravel lot at 3751 Beach Ave.	Hard Mod 20-50m	49.4311 -123.6753 190	Rock outcrop E of parking area	49.4362 -123.6848 190	In front of windowless wooden building after scrambling past rock point
LOSC-3	Mission Point	Easy access from Hwy	Hard Mod >50m	49.4473 -123.7292 250	W end of walkway	49.4391 -123.7241 195	W bank of Chapman Creek

Transect Code	Transect Name	Access	BCME Classification	Starting point		Ending point	
			Sub Exp Dep	Lat Long Magnetic bearing	Description	Lat Long Magnetic bearing	Description
LOSC-4	Wakefield Creek	Access from Mason Rd, next door to Wakefield Inn	Hard Mod >50m	49.4661 -123.7945 165	~550 m E of Mason Rd. at rocks forming point	49.4677 -123.8074 165	~450 m W of Mason Rd, at rocks with No Trespass sign
LOSC-5	Roberts Creek	Municipal Park, just down road from Roberts Creek General Store, on Roberts Creek Road	Mud Mod 20-50m	49.4182 -123.6419	Public jetty	49.4227 -123.6545	Point at first set of rocks on SE
UPSC-1	Saltery Bay	Prov Park boat launch, just off Hwy	Mud Low <20m	49.7807 -124.2143 155	At point E of boat launch	49.7801 -124.2276 155	Just E of 2nd point heading W from boat launch
UPSC-2	Palm Beach	Prov Park access from Lang Bay Rd., must walk past gate and through ball field to reach beach	Mud Low >50m	49.7709 -124.3448 165	Rocky point to W of park	49.7739 -124.3447 165	Just past cove at end of beach, next to large standing stump
UPSC-3	Myrtle Rocks	Pull-off from highway, Breakwall jetty is near midway point	Mud Low >50m	49.7936 -124.4784 180	At pilings ~300 m W of break wall jetty	49.7920 -124.4660 180	~250 W of point which lies SE of the break wall jetty
UPSC-4	Powell River South	S end of Powell River, where road begins to leave oceanside	Mud Low >50m	49.8110 -124.5269 235	~400 m S of elevated parking site, N of Grief Point	49.8204 -124.5254 245	Between 2 buoys, no landmark, must use gps to find end
UPSC-5	Willingdon Beach	Willingdon Beach Park, N end of Powell River	Mud Low >50m	49.8444 -124.5304 210	In elevated lot at yellow concrete barriers	49.8525 -124.5362 220	At large tree root, use trail above beach access
UPSC-6	Sliammon Church	N of Powell River in Sliammon Town site, park on ocean side of Sliammon River	Mud Mod >50m	49.8954 -124.6074 190	N bank of Sliammon Creek	49.8961 -124.6201 210	Small green house 6621 Waterfront, had permission from owner to cross yard
UPSC-7	Grief Point	Windsor Road to Victoria, parking at small park near point	Mud Low >50m	49.8021 -124.5189 not recorded	Breakwall for Marina, 550m E of Grief Point	49.8088 -124.5261 not recorded	400 m NW of point, ~75 , before boulders begin on sandy beach

7.2 Appendix 2: Raw Survey Data (summarized by transect, year, species)

Transect	Year	Species	Total	F	M	M_{ADU}	M_{1Y}
BBFD-1	2003	BLSC	108	17	34	32	2
BBFD-1	2003	BUFF	4	-	-	-	-
BBFD-1	2003	SUSC	490	68	190	178	12
BBFD-1	2003	WWSC	620	-	-	-	-
BBFD-1	2004	BLSC	2	1	1	1	0
BBFD-1	2004	BUFF	7	2	-	5	-
BBFD-1	2004	SUSC	77	26	51	51	0
BBFD-1	2004	WWSC	260	101	-	159	-
BBFD-2	2003	BUFF	25	-	-	-	-
BBFD-2	2003	COGO	3	1	2	2	0
BBFD-2	2003	SUSC	17	2	15	14	1
BBFD-2	2003	WWSC	54	-	-	-	-
BBFD-2	2004	BLSC	4	1	3	2	1
BBFD-2	2004	BUFF	13	6	-	7	-
BBFD-2	2004	COGO	2	0	2	1	1
BBFD-2	2004	LTDU	2	0	-	2	-
BBFD-2	2004	RBME	1	1	-	0	-
BBFD-2	2004	SUSC	70	14	56	51	5
BBFD-2	2004	WWSC	121	45	-	76	-
BBFD-3	2003	BUFF	11	-	-	-	-
BBFD-3	2003	COGO	14	7	7	5	2
BBFD-3	2003	HADU	22	9	13	10	3
BBFD-3	2003	RBME	10	-	-	-	-
BBFD-3	2004	BAGO	12	4	8	8	0
BBFD-3	2004	BUFF	3	2	-	1	-
BBFD-3	2004	COGO	7	0	7	6	1
BBFD-3	2004	HADU	17	8	9	8	1
BBFD-3	2004	LTDU	1	1	-	0	-
BBFD-3	2004	RBME	16	15	-	1	-
BBFD-4	2003	BUFF	3	-	-	-	-
BBFD-4	2003	COGO	6	2	4	3	1
BBFD-4	2003	HADU	19	10	9	8	1
BBFD-4	2003	RBME	5	-	-	-	-
BBFD-4	2004	BAGO	3	2	1	1	0
BBFD-4	2004	BUFF	21	7	-	14	-
BBFD-4	2004	COGO	14	3	11	10	1
BBFD-4	2004	HADU	21	12	9	9	0
BBFD-4	2004	RBME	5	4	-	1	-
BBFD-4	2004	SUSC	1	0	1	1	0
BBFD-4	2004	WWSC	138	89	-	49	-
BBFD-5	2004	BUFF	57	34	-	23	-
BBFD-5	2004	COGO	6	0	6	6	0

Transect	Year	Species	Total	F	M	M_{ADU}	M_{1Y}
BBFD-5	2004	RBME	2	1	-	1	-
BBFD-5	2004	SUSC	8	4	4	4	0
BBFD-5	2004	WWSC	20	9	-	11	-
BBFD-6	2004	BAGO	10	3	7	6	1
BBFD-6	2004	BUFF	2	2	-	0	-
BBFD-6	2004	COGO	13	4	9	9	0
BBFD-6	2004	LTDU	7	2	-	5	-
BBFD-6	2004	SUSC	246	77	169	137	32
BBFD-6	2004	WWSC	3	1	-	2	-
BBFD-7	2004	BAGO	5	2	3	3	0
BBFD-7	2004	SUSC	109	54	55	33	22
BIEB-1	2003	BAGO	1	0	1	1	0
BIEB-1	2003	BUFF	3	-	-	-	-
BIEB-1	2003	COGO	2	0	2	2	0
BIEB-1	2003	RBME	21	-	-	-	-
BIEB-1	2003	SUSC	182	49	79	75	4
BIEB-1	2003	WWSC	31	-	-	-	-
BIEB-1	2004	BAGO	2	1	1	1	0
BIEB-1	2004	BUFF	3	0	-	3	-
BIEB-1	2004	COGO	1	0	1	1	0
BIEB-1	2004	RBME	5	3	-	2	-
BIEB-1	2004	SUSC	1	0	1	1	0
BIEB-2	2003	BAGO	10	4	6	6	0
BIEB-2	2003	BUFF	1	-	-	-	-
BIEB-2	2003	COGO	6	1	5	5	0
BIEB-2	2003	SUSC	35	16	19	17	2
BIEB-2	2003	WWSC	25	-	-	-	-
BIEB-2	2004	BAGO	8	2	6	6	0
BIEB-2	2004	BUFF	1	0	-	1	-
BIEB-3	2003	BAGO	20	10	10	10	0
BIEB-3	2003	BUFF	2	-	-	-	-
BIEB-3	2003	COGO	1	0	1	1	0
BIEB-3	2003	HADU	6	4	2	2	0
BIEB-3	2003	RBME	4	-	-	-	-
BIEB-3	2003	SUSC	32	14	18	16	2
BIEB-3	2004	BAGO	27	13	14	14	0
BIEB-3	2004	BUFF	2	1	-	1	-
BIEB-3	2004	HADU	6	4	2	2	0
BIEB-3	2004	RBME	2	0	-	2	-
BIEB-4	2003	BAGO	65	29	36	33	3
BIEB-4	2003	BUFF	5	-	-	-	-
BIEB-4	2003	COGO	6	1	5	5	0
BIEB-4	2003	HADU	5	3	2	2	0
BIEB-4	2003	SUSC	71	31	40	40	0
BIEB-4	2004	BAGO	88	34	54	51	3

Transect	Year	Species	Total	F	M	M_{ADU}	M_{1Y}
BIEB-4	2004	BUFF	4	3	-	1	-
BIEB-4	2004	HADU	2	1	1	0	1
BIEB-5	2003	BAGO	21	9	12	12	0
BIEB-5	2003	COGO	2	1	1	1	0
BIEB-5	2003	HADU	3	2	1	1	0
BIEB-5	2003	SUSC	78	38	40	34	6
BIEB-5	2004	BAGO	30	17	13	13	0
BIEB-5	2004	BUFF	2	1	-	1	-
BIEB-5	2004	HADU	6	3	3	3	0
BIEB-5	2004	RBME	1	0	-	1	-
BIEB-6	2003	BAGO	67	29	38	36	2
BIEB-6	2003	BUFF	3	-	-	-	-
BIEB-6	2003	COGO	6	3	3	3	0
BIEB-6	2003	RBME	1	-	-	-	-
BIEB-6	2003	SUSC	4	2	2	1	1
BIEB-6	2004	BAGO	18	9	9	7	2
BIEB-6	2004	BUFF	2	2	-	0	-
BIEB-6	2004	COGO	3	1	2	2	0
BIEB-6	2004	RBME	6	1	-	5	-
BIEB-7	2003	BAGO	7	2	5	3	2
BIEB-7	2003	BUFF	8	-	-	-	-
BIEB-7	2003	COGO	54	11	43	42	1
BIEB-7	2003	SUSC	130	60	70	63	7
BIEB-7	2004	BAGO	50	14	36	34	2
BIEB-7	2004	COGO	3	0	3	3	0
BIEB-7	2004	HADU	4	1	3	3	0
BIEB-7	2004	SUSC	9	5	4	4	0
BSHI-1	2003	BUFF	31	-	-	-	-
BSHI-1	2003	COGO	29	10	19	18	1
BSHI-1	2003	COME	2	-	-	-	-
BSHI-1	2003	LTDU	5	-	-	-	-
BSHI-1	2003	RBME	6	-	-	-	-
BSHI-1	2003	SUSC	78	25	53	42	11
BSHI-1	2003	WWSC	96	-	-	-	-
BSHI-1	2004	BUFF	35	15	-	20	-
BSHI-1	2004	COGO	45	11	34	34	0
BSHI-1	2004	COME	1	1	-	0	-
BSHI-1	2004	HADU	23	9	14	13	1
BSHI-1	2004	RBME	12	2	-	10	-
BSHI-1	2004	SUSC	181	63	118	113	5
BSHI-1	2004	WWSC	436	202	-	234	-
BSHI-2	2003	BAGO	29	9	20	20	0
BSHI-2	2003	BLSC	44	14	30	22	8
BSHI-2	2003	BUFF	43	-	-	-	-
BSHI-2	2003	COGO	36	13	23	20	3

Transect	Year	Species	Total	F	M	M_{ADU}	M_{1Y}
BSHI-2	2003	COME	3	-	-	-	-
BSHI-2	2003	HADU	36	15	21	20	1
BSHI-2	2003	LTDU	1	-	-	-	-
BSHI-2	2003	RBME	30	-	-	-	-
BSHI-2	2003	SUSC	151	55	96	94	2
BSHI-2	2003	WWSC	111	-	-	-	-
BSHI-2	2004	BAGO	5	2	3	3	0
BSHI-2	2004	BLSC	6	2	4	4	0
BSHI-2	2004	BUFF	9	5	-	4	-
BSHI-2	2004	COGO	11	2	9	5	4
BSHI-2	2004	HADU	9	3	6	6	0
BSHI-2	2004	SUSC	46	13	33	33	0
BSHI-2	2004	WWSC	41	20	-	21	-
BSHI-3	2003	BAGO	5	2	3	3	0
BSHI-3	2003	BUFF	32	-	-	-	-
BSHI-3	2003	COGO	6	1	5	5	0
BSHI-3	2003	HADU	10	4	6	6	0
BSHI-3	2003	RBME	5	-	-	-	-
BSHI-3	2003	SUSC	115	41	74	71	3
BSHI-3	2003	WWSC	72	-	-	-	-
BSHI-3	2004	BAGO	2	1	1	1	0
BSHI-3	2004	BUFF	17	7	-	10	-
BSHI-3	2004	COGO	18	6	12	10	2
BSHI-3	2004	COME	2	1	-	1	-
BSHI-3	2004	HADU	8	3	5	3	2
BSHI-3	2004	RBME	4	1	-	3	-
BSHI-3	2004	SUSC	62	20	42	41	1
BSHI-3	2004	WWSC	11	4	-	7	-
BSHI-4	2003	BLSC	15	5	10	9	1
BSHI-4	2003	BUFF	37	-	-	-	-
BSHI-4	2003	COGO	38	12	26	25	1
BSHI-4	2003	HADU	75	29	46	43	3
BSHI-4	2003	SUSC	29	14	15	15	0
BSHI-4	2003	WWSC	104	-	-	-	-
BSHI-4	2004	BLSC	124	30	94	92	2
BSHI-4	2004	BUFF	58	26	-	32	-
BSHI-4	2004	COGO	31	8	23	23	0
BSHI-4	2004	HADU	111	48	63	61	2
BSHI-4	2004	RBME	2	2	-	0	-
BSHI-4	2004	SUSC	22	8	14	14	0
BSHI-4	2004	WWSC	171	69	-	102	-
BSHI-5	2003	BAGO	1	0	1	0	1
BSHI-5	2003	BLSC	16	9	7	4	3
BSHI-5	2003	BUFF	11	-	-	-	-
BSHI-5	2003	COGO	5	2	3	2	1

Transect	Year	Species	Total	F	M	M_{ADU}	M_{1Y}
BSHI-5	2003	COME	6	-	-	-	-
BSHI-5	2003	HADU	29	11	18	15	3
BSHI-5	2003	RBME	13	-	-	-	-
BSHI-5	2003	SUSC	13	5	8	7	1
BSHI-5	2003	WWSC	24	-	-	-	-
BSHI-5	2004	BLSC	4	2	2	2	0
BSHI-5	2004	BUFF	15	4	-	11	-
BSHI-5	2004	COGO	13	7	6	5	1
BSHI-5	2004	COME	1	0	-	1	-
BSHI-5	2004	HADU	23	8	15	11	4
BSHI-5	2004	RBME	2	0	-	2	-
BSHI-5	2004	SUSC	10	2	8	8	0
BSHI-5	2004	WWSC	15	7	-	8	-
BSHI-6	2003	BLSC	84	25	59	54	5
BSHI-6	2003	BUFF	13	-	-	-	-
BSHI-6	2003	COGO	3	0	3	3	0
BSHI-6	2003	HADU	58	22	36	31	5
BSHI-6	2003	RBME	5	-	-	-	-
BSHI-6	2003	WWSC	5	-	-	-	-
BSHI-6	2004	BLSC	30	9	21	19	2
BSHI-6	2004	BUFF	8	3	-	5	-
BSHI-6	2004	COGO	2	1	1	0	1
BSHI-6	2004	COME	5	1	-	4	-
BSHI-6	2004	HADU	103	42	61	54	7
BSHI-6	2004	RBME	6	5	-	1	-
BSHI-6	2004	SUSC	4	1	3	3	0
BSHI-6	2004	WWSC	8	4	-	4	-
BSHI-7	2003	BLSC	6	1	5	4	1
BSHI-7	2003	BUFF	17	-	-	-	-
BSHI-7	2003	COGO	5	2	3	3	0
BSHI-7	2003	HADU	31	13	18	17	1
BSHI-7	2003	LTDU	4	-	-	-	-
BSHI-7	2003	SUSC	51	19	32	30	2
BSHI-7	2003	WWSC	14	-	-	-	-
BSHI-7	2004	BLSC	18	7	11	11	0
BSHI-7	2004	BUFF	28	16	-	12	-
BSHI-7	2004	COGO	8	3	5	5	0
BSHI-7	2004	HADU	60	26	34	32	2
BSHI-7	2004	RBME	3	2	-	1	-
BSHI-7	2004	SUSC	30	12	18	18	0
BSHI-8	2003	BUFF	73	-	-	-	-
BSHI-8	2003	COGO	29	10	19	14	5
BSHI-8	2003	COME	1	-	-	-	-
BSHI-8	2003	HADU	26	12	14	14	0
BSHI-8	2003	RBME	15	-	-	-	-

Transect	Year	Species	Total	F	M	M_{ADU}	M_{1Y}
BSHI-8	2003	SUSC	9	3	6	6	0
BSHI-8	2003	WWSC	2	-	-	-	-
BSHI-8	2004	BLSC	28	6	22	18	4
BSHI-8	2004	BUFF	43	20	-	23	-
BSHI-8	2004	COGO	36	10	26	25	1
BSHI-8	2004	COME	6	1	-	5	-
BSHI-8	2004	HADU	15	8	7	7	0
BSHI-8	2004	HOME	2	1	-	1	-
BSHI-8	2004	RBME	34	23	-	11	-
BSHI-8	2004	SUSC	29	13	16	16	0
BSHI-8	2004	WWSC	2	1	-	1	-
BSHI-9	2004	BLSC	31	12	19	16	3
BSHI-9	2004	BUFF	4	3	-	1	-
BSHI-9	2004	COGO	12	2	10	9	1
BSHI-9	2004	COME	3	2	-	1	-
BSHI-9	2004	HADU	56	21	35	29	6
BSHI-9	2004	RBME	7	5	-	2	-
BSHI-9	2004	SUSC	4	2	2	2	0
BSHI-9	2004	WWSC	34	15	-	19	-
BSHI-10	2004	BLSC	3	0	3	3	0
BSHI-10	2004	BUFF	13	7	-	6	-
BSHI-10	2004	HADU	49	19	30	26	4
BSHI-10	2004	RBME	3	2	-	1	-
BSHI-10	2004	SUSC	21	2	19	17	2
BSHI-10	2004	WWSC	9	4	-	5	-
BSHI-11	2004	BAGO	25	8	17	14	3
BSHI-11	2004	BUFF	28	10	-	18	-
BSHI-11	2004	COGO	37	9	28	17	11
BSHI-11	2004	HADU	66	29	37	35	2
BSHI-11	2004	RBME	11	7	-	4	-
BSHI-11	2004	SUSC	15	4	11	11	0
BSHI-11	2004	WWSC	35	20	-	15	-
BSHI-12	2004	BAGO	22	6	16	10	6
BSHI-12	2004	BLSC	165	47	118	108	10
BSHI-12	2004	BUFF	24	10	-	14	-
BSHI-12	2004	COGO	70	24	46	38	8
BSHI-12	2004	COME	1	1	-	0	-
BSHI-12	2004	HADU	18	7	11	8	3
BSHI-12	2004	LTDU	4	1	-	3	-
BSHI-12	2004	SUSC	2	1	1	1	0
BSHI-12	2004	WWSC	160	101	-	59	-
CRCX-1	2003	BLSC	1	1	0	0	0
CRCX-1	2003	BUFF	32	-	-	-	-
CRCX-1	2003	COGO	19	4	15	14	1
CRCX-1	2003	HADU	29	12	17	16	1

Transect	Year	Species	Total	F	M	M_{ADU}	M_{1Y}
CRCX-1	2003	LTDU	7	-	-	-	-
CRCX-1	2003	RBME	3	-	-	-	-
CRCX-1	2003	SUSC	58	19	39	37	2
CRCX-1	2003	WWSC	51	-	-	-	-
CRCX-1	2004	BUFF	16	5	-	11	-
CRCX-1	2004	COGO	3	0	3	3	0
CRCX-1	2004	HADU	33	15	18	18	0
CRCX-1	2004	LTDU	4	1	-	3	-
CRCX-1	2004	RBME	4	2	-	2	-
CRCX-1	2004	SUSC	7	1	6	6	0
CRCX-1	2004	WWSC	15	5	-	10	-
CRCX-2	2003	BUFF	68	-	-	-	-
CRCX-2	2003	COGO	18	11	7	7	0
CRCX-2	2003	COME	3	-	-	-	-
CRCX-2	2003	HADU	37	17	20	20	0
CRCX-2	2003	LTDU	15	-	-	-	-
CRCX-2	2003	RBME	2	-	-	-	-
CRCX-2	2003	SUSC	77	21	56	51	5
CRCX-2	2004	BUFF	17	12	-	5	-
CRCX-2	2004	COGO	1	0	1	1	0
CRCX-2	2004	COME	1	1	-	0	-
CRCX-2	2004	HADU	5	1	4	4	0
CRCX-2	2004	RBME	1	1	-	0	-
CRCX-2	2004	SUSC	27	3	24	24	0
CRCX-3	2003	BLSC	1	0	1	1	0
CRCX-3	2003	BUFF	38	-	-	-	-
CRCX-3	2003	COGO	5	3	2	0	2
CRCX-3	2003	COME	26	-	-	-	-
CRCX-3	2003	HADU	53	22	31	31	0
CRCX-3	2003	RBME	1	-	-	-	-
CRCX-3	2003	SUSC	15	2	13	13	0
CRCX-3	2004	BUFF	20	12	-	8	-
CRCX-3	2004	COGO	14	11	3	2	1
CRCX-3	2004	COME	4	3	-	1	-
CRCX-3	2004	HADU	30	13	17	15	2
CRCX-3	2004	LTDU	1	0	-	1	-
CRCX-3	2004	RBME	2	2	-	0	-
CRCX-3	2004	SUSC	25	5	20	20	0
CRCX-4	2003	BAGO	1	1	0	0	0
CRCX-4	2003	BLSC	7	3	4	4	0
CRCX-4	2003	BUFF	7	-	-	-	-
CRCX-4	2003	COGO	1	0	1	0	1
CRCX-4	2003	RBME	3	-	-	-	-
CRCX-4	2003	SUSC	14	3	11	11	0
CRCX-4	2003	WWSC	8	-	-	-	-

Transect	Year	Species	Total	F	M	M_{ADU}	M_{1Y}
CRCX-4	2004	BUFF	7	6	-	1	-
CRCX-4	2004	COGO	2	1	1	0	1
CRCX-4	2004	COME	2	2	-	0	-
CRCX-4	2004	HADU	8	2	6	5	1
CRCX-4	2004	SUSC	17	4	13	13	0
CRCX-5	2003	BLSC	9	1	8	8	0
CRCX-5	2003	BUFF	36	-	-	-	-
CRCX-5	2003	COGO	70	39	32	29	3
CRCX-5	2003	HADU	20	10	10	10	0
CRCX-5	2003	LTDU	5	-	-	-	-
CRCX-5	2003	SUSC	78	25	53	46	7
CRCX-5	2003	WWSC	11	-	-	-	-
CRCX-5	2004	BAGO	2	1	1	1	0
CRCX-5	2004	BLSC	15	2	13	13	0
CRCX-5	2004	BUFF	38	13	-	25	-
CRCX-5	2004	COGO	28	13	15	12	3
CRCX-5	2004	COME	8	2	-	6	-
CRCX-5	2004	HADU	27	14	13	12	1
CRCX-5	2004	RBME	1	1	-	0	-
CRCX-5	2004	SUSC	123	44	79	76	3
CRCX-5	2004	WWSC	142	73	-	69	-
CRCX-6	2003	BLSC	1	0	1	1	0
CRCX-6	2003	BUFF	10	-	-	-	-
CRCX-6	2003	HADU	46	21	25	25	0
CRCX-6	2003	LTDU	2	-	-	-	-
CRCX-6	2003	RBME	4	-	-	-	-
CRCX-6	2003	SUSC	8	2	6	4	2
CRCX-6	2004	BUFF	16	8	-	8	-
CRCX-6	2004	COME	1	0	-	1	-
CRCX-6	2004	HADU	30	15	15	14	1
CRCX-6	2004	RBME	3	1	-	2	-
CRCX-6	2004	SUSC	1	0	1	1	0
CRCX-7	2003	BLSC	5	1	4	4	0
CRCX-7	2003	BUFF	37	-	-	-	-
CRCX-7	2003	COGO	15	5	10	10	0
CRCX-7	2003	HADU	2	1	1	1	0
CRCX-7	2003	SUSC	20	6	14	11	3
CRCX-7	2004	BUFF	34	21	-	13	-
CRCX-7	2004	COGO	17	4	13	11	2
CRCX-7	2004	HADU	3	2	1	0	1
CRCX-7	2004	SUSC	37	8	29	25	4
CRCX-8	2003	BLSC	64	20	44	34	10
CRCX-8	2003	BUFF	47	-	-	-	-
CRCX-8	2003	COGO	24	4	20	19	1
CRCX-8	2003	HADU	90	35	55	49	6

Transect	Year	Species	Total	F	M	M_{ADU}	M_{1Y}
CRCX-8	2003	RBME	17	-	-	-	-
CRCX-8	2003	SUSC	15	2	13	12	1
CRCX-8	2003	WWSC	49	-	-	-	-
CRCX-8	2004	BLSC	61	26	35	31	4
CRCX-8	2004	BUFF	67	39	-	28	-
CRCX-8	2004	COGO	22	4	18	18	0
CRCX-8	2004	HADU	58	25	33	32	1
CRCX-8	2004	HOME	2	1	-	1	-
CRCX-8	2004	LTDU	7	1	-	6	-
CRCX-8	2004	RBME	16	8	-	8	-
CRCX-8	2004	SUSC	7	2	5	5	0
CRCX-8	2004	WWSC	39	20	-	19	-
CRCX-9	2003	BLSC	14	5	9	7	2
CRCX-9	2003	BUFF	46	-	-	-	-
CRCX-9	2003	COGO	16	7	9	9	0
CRCX-9	2003	HADU	29	11	18	17	1
CRCX-9	2003	RBME	3	-	-	-	-
CRCX-9	2003	SUSC	7	3	4	3	1
CRCX-9	2003	WWSC	27	-	-	-	-
CRCX-9	2004	BLSC	12	6	6	6	0
CRCX-9	2004	BUFF	54	26	-	28	-
CRCX-9	2004	COGO	25	12	13	8	5
CRCX-9	2004	COME	1	1	-	0	-
CRCX-9	2004	HADU	53	19	34	32	2
CRCX-9	2004	LTDU	1	1	-	0	-
CRCX-9	2004	RBME	3	0	-	3	-
CRCX-9	2004	SUSC	8	2	6	5	1
CRCX-9	2004	WWSC	24	11	-	13	-
CRCX-10	2003	BLSC	8	7	1	1	0
CRCX-10	2003	BUFF	6	-	-	-	-
CRCX-10	2003	COGO	2	2	0	0	0
CRCX-10	2003	HADU	13	7	6	6	0
CRCX-10	2003	RBME	1	-	-	-	-
CRCX-10	2003	SUSC	2	0	2	0	2
CRCX-10	2003	WWSC	15	-	-	-	-
CRCX-10	2004	BUFF	5	5	-	0	-
CRCX-10	2004	COGO	5	3	2	2	0
CRCX-10	2004	HADU	4	2	2	2	0
CRCX-10	2004	RBME	3	2	-	1	-
CRCX-10	2004	WWSC	20	8	-	12	-
CRCX-11	2004	BLSC	4	2	2	2	0
CRCX-11	2004	BUFF	28	16	-	12	-
CRCX-11	2004	COGO	27	8	19	13	6
CRCX-11	2004	HADU	41	19	22	20	2
CRCX-11	2004	LTDU	1	0	-	1	-

Transect	Year	Species	Total	F	M	M_{ADU}	M_{1Y}
CRCX-11	2004	RBME	2	1	-	1	-
CRCX-11	2004	SUSC	31	7	24	24	0
CRCX-11	2004	WWSC	3	2	-	1	-
CRCX-12	2004	BAGO	1	0	1	1	0
CRCX-12	2004	BLSC	3	0	3	3	0
CRCX-12	2004	BUFF	11	9	-	2	-
CRCX-12	2004	COGO	3	3	0	0	0
CRCX-12	2004	COME	3	1	-	2	-
CRCX-12	2004	HADU	37	19	18	17	1
CRCX-12	2004	LTDU	1	1	-	0	-
CRCX-12	2004	RBME	11	10	-	1	-
CRCX-12	2004	SUSC	2	1	1	1	0
CRCX-12	2004	WWSC	3	3	-	0	-
DBFC-1	2003	BLSC	161	30	133	109	24
DBFC-1	2003	BUFF	26	-	-	-	-
DBFC-1	2003	COGO	20	1	19	15	4
DBFC-1	2003	HADU	20	9	11	11	0
DBFC-1	2003	RBME	14	-	-	-	-
DBFC-1	2003	SUSC	33	2	31	29	2
DBFC-1	2003	WWSC	160	-	-	-	-
DBFC-1	2004	BAGO	1	0	1	1	0
DBFC-1	2004	BLSC	48	14	34	29	5
DBFC-1	2004	BUFF	21	11	-	10	-
DBFC-1	2004	COGO	18	1	17	15	2
DBFC-1	2004	HADU	23	10	13	12	1
DBFC-1	2004	RBME	11	5	-	6	-
DBFC-1	2004	SUSC	14	4	10	10	0
DBFC-1	2004	WWSC	92	47	-	45	-
DBFC-2	2003	BAGO	1	0	1	0	1
DBFC-2	2003	BUFF	2	-	-	-	-
DBFC-2	2003	COGO	1	0	1	1	0
DBFC-2	2003	HADU	20	9	11	11	0
DBFC-2	2003	RBME	19	-	-	-	-
DBFC-2	2003	SUSC	38	7	31	31	0
DBFC-2	2004	BUFF	11	3	-	8	-
DBFC-2	2004	COGO	1	0	1	1	0
DBFC-2	2004	HADU	21	10	11	11	0
DBFC-2	2004	RBME	1	1	-	0	-
DBFC-2	2004	SUSC	15	5	10	10	0
DBFC-3	2003	BLSC	60	14	46	42	4
DBFC-3	2003	BUFF	67	-	-	-	-
DBFC-3	2003	COGO	69	51	18	17	1
DBFC-3	2003	HADU	35	19	16	15	1
DBFC-3	2003	LTDU	3	-	-	-	-
DBFC-3	2003	SUSC	8	2	6	6	0

Transect	Year	Species	Total	F	M	M_{ADU}	M_{1Y}
DBFC-3	2003	WWSC	3	-	-	-	-
DBFC-3	2004	BLSC	69	21	48	44	4
DBFC-3	2004	BUFF	21	11	-	10	-
DBFC-3	2004	COGO	22	12	10	10	0
DBFC-3	2004	HADU	63	27	36	35	1
DBFC-3	2004	LTDU	3	2	-	1	-
DBFC-3	2004	SUSC	3	1	2	2	0
DBFC-3	2004	WWSC	91	32	-	59	-
DBFC-4	2003	BLSC	3	2	1	1	0
DBFC-4	2003	BUFF	14	-	-	-	-
DBFC-4	2003	COGO	2	1	1	0	1
DBFC-4	2003	COME	6	-	-	-	-
DBFC-4	2003	HADU	25	12	13	13	0
DBFC-4	2003	RBME	9	-	-	-	-
DBFC-4	2003	SUSC	29	2	27	27	0
DBFC-4	2004	BUFF	8	3	-	5	-
DBFC-4	2004	COGO	9	3	6	6	0
DBFC-4	2004	HADU	24	10	14	12	2
DBFC-4	2004	RBME	5	4	-	1	-
DBFC-4	2004	SUSC	12	2	10	9	1
DBFC-5	2003	BLSC	5	1	4	4	0
DBFC-5	2003	BUFF	12	-	-	-	-
DBFC-5	2003	COGO	6	1	5	5	0
DBFC-5	2003	SUSC	97	9	83	83	0
DBFC-5	2003	WWSC	53	-	-	-	-
DBFC-5	2004	BLSC	11	2	9	7	2
DBFC-5	2004	BUFF	20	11	-	9	-
DBFC-5	2004	COGO	2	2	0	0	0
DBFC-5	2004	COME	3	0	-	3	-
DBFC-5	2004	SUSC	33	4	29	29	0
DBFC-5	2004	WWSC	93	47	-	46	-
DBFC-6	2003	BLSC	37	13	24	21	3
DBFC-6	2003	BUFF	19	-	-	-	-
DBFC-6	2003	COGO	13	6	7	7	0
DBFC-6	2003	HADU	27	13	14	13	1
DBFC-6	2003	SUSC	48	7	41	41	0
DBFC-6	2003	WWSC	10	-	-	-	-
DBFC-6	2004	BAGO	1	0	1	0	1
DBFC-6	2004	BLSC	102	14	88	70	18
DBFC-6	2004	BUFF	9	4	-	5	-
DBFC-6	2004	COGO	18	4	14	13	1
DBFC-6	2004	COME	1	1	-	0	-
DBFC-6	2004	HADU	20	9	11	11	0
DBFC-6	2004	RBME	1	0	-	1	-
DBFC-6	2004	SUSC	16	2	14	14	0

Transect	Year	Species	Total	F	M	M_{ADU}	M_{1Y}
DBFC-6	2004	WWSC	59	29	-	30	-
DIIS-1	2003	BLSC	4	0	4	3	1
DIIS-1	2003	BUFF	6	-	-	-	-
DIIS-1	2003	COGO	11	2	2	1	1
DIIS-1	2003	HADU	37	16	21	18	3
DIIS-1	2003	LTDU	3	-	-	-	-
DIIS-1	2003	RBME	5	-	-	-	-
DIIS-1	2003	SUSC	12	6	6	6	0
DIIS-1	2004	BLSC	4	1	3	2	1
DIIS-1	2004	BUFF	1	1	-	0	-
DIIS-1	2004	COGO	1	0	1	1	0
DIIS-1	2004	HADU	26	9	17	16	1
DIIS-1	2004	RBME	10	4	-	6	-
DIIS-1	2004	SUSC	2	0	2	2	0
DIIS-2	2003	BLSC	16	4	12	9	3
DIIS-2	2003	BUFF	17	-	-	-	-
DIIS-2	2003	COGO	13	8	5	4	1
DIIS-2	2003	HADU	89	38	51	47	4
DIIS-2	2003	RBME	7	-	-	-	-
DIIS-2	2003	SUSC	6	3	3	3	0
DIIS-2	2003	WWSC	41	-	-	-	-
DIIS-2	2004	BLSC	3	1	2	2	0
DIIS-2	2004	BUFF	17	12	-	5	-
DIIS-2	2004	COGO	8	4	4	4	0
DIIS-2	2004	HADU	48	20	28	28	0
DIIS-2	2004	RBME	3	2	-	1	-
DIIS-2	2004	SUSC	11	4	7	7	0
DIIS-2	2004	WWSC	8	1	-	7	-
DIIS-3	2003	BLSC	2	0	2	2	0
DIIS-3	2003	BUFF	3	-	-	-	-
DIIS-3	2003	HADU	39	10	29	27	2
DIIS-3	2003	RBME	5	-	-	-	-
DIIS-3	2003	WWSC	6	-	-	-	-
DIIS-3	2004	BLSC	3	0	3	3	0
DIIS-3	2004	BUFF	1	1	-	0	-
DIIS-3	2004	HADU	13	6	7	6	1
DIIS-3	2004	RBME	10	7	-	3	-
DIIS-3	2004	SUSC	3	0	3	3	0
DIIS-3	2004	WWSC	11	5	-	6	-
DIIS-4	2003	BAGO	4	1	3	3	0
DIIS-4	2003	BUFF	8	-	-	-	-
DIIS-4	2003	COGO	5	2	3	3	0
DIIS-4	2003	HADU	20	10	10	10	0
DIIS-4	2003	RBME	7	-	-	-	-
DIIS-4	2003	SUSC	25	5	20	19	1

Transect	Year	Species	Total	F	M	M_{ADU}	M_{1Y}
DIIS-4	2003	WWSC	158	-	-	-	-
DIIS-4	2004	BUFF	12	4	-	8	-
DIIS-4	2004	COGO	6	2	4	4	0
DIIS-4	2004	HADU	9	4	5	5	0
DIIS-4	2004	RBME	6	3	-	3	-
DIIS-4	2004	SUSC	7	4	3	3	0
DIIS-4	2004	WWSC	106	45	-	61	-
DIIS-5	2004	BUFF	3	1	-	2	-
DIIS-5	2004	HADU	29	13	16	14	2
DIIS-5	2004	RBME	9	5	-	4	-
DIIS-5	2004	SUSC	11	3	8	7	1
DIIS-6	2004	COME	5	5	-	0	-
DIIS-6	2004	HADU	8	3	5	4	1
DIIS-6	2004	RBME	1	1	-	0	-
DIIS-6	2004	SUSC	1	0	1	1	0
LOSC-1	2003	BAGO	57	23	34	34	0
LOSC-1	2003	BUFF	11	-	-	-	-
LOSC-1	2003	COGO	8	5	3	3	0
LOSC-1	2003	HADU	3	1	2	2	0
LOSC-1	2003	RBME	4	-	-	-	-
LOSC-1	2003	SUSC	6	2	4	4	0
LOSC-1	2004	BAGO	25	7	18	18	0
LOSC-1	2004	BUFF	2	1	-	1	-
LOSC-1	2004	COGO	3	0	3	3	0
LOSC-1	2004	RBME	2	1	-	1	-
LOSC-2	2003	BAGO	56	30	26	25	1
LOSC-2	2003	BLSC	7	2	5	5	0
LOSC-2	2003	BUFF	14	-	-	-	-
LOSC-2	2003	COME	1	-	-	-	-
LOSC-2	2003	HADU	8	4	4	4	0
LOSC-2	2003	SUSC	10	8	2	2	0
LOSC-2	2004	BAGO	11	7	4	4	0
LOSC-2	2004	BLSC	6	1	5	5	0
LOSC-2	2004	BUFF	10	5	-	5	-
LOSC-2	2004	HADU	5	2	3	3	0
LOSC-2	2004	SUSC	1	1	0	0	0
LOSC-3	2003	BAGO	10	3	7	7	0
LOSC-3	2003	BLSC	33	9	25	22	3
LOSC-3	2003	BUFF	2	-	-	-	-
LOSC-3	2003	COGO	9	4	5	5	0
LOSC-3	2003	HADU	6	3	3	3	0
LOSC-3	2003	RBME	9	-	-	-	-
LOSC-3	2003	SUSC	34	12	22	22	0
LOSC-3	2003	WWSC	5	-	-	-	-
LOSC-3	2004	BLSC	11	3	8	8	0

Transect	Year	Species	Total	F	M	M_{ADU}	M_{1Y}
LOSC-3	2004	HADU	8	4	4	2	2
LOSC-3	2004	RBME	4	3	-	1	-
LOSC-3	2004	SUSC	19	5	14	14	0
LOSC-3	2004	WWSC	6	3	-	3	-
LOSC-4	2003	BAGO	18	9	9	9	0
LOSC-4	2003	BUFF	4	-	-	-	-
LOSC-4	2003	COGO	3	0	3	2	1
LOSC-4	2003	HADU	4	2	2	2	0
LOSC-4	2003	SUSC	13	5	8	8	0
LOSC-4	2004	BAGO	3	2	1	1	0
LOSC-4	2004	BUFF	1	0	-	1	-
LOSC-4	2004	COGO	6	2	4	4	0
LOSC-4	2004	HADU	9	4	5	5	0
LOSC-4	2004	RBME	3	1	-	2	-
LOSC-4	2004	SUSC	14	6	8	8	0
LOSC-5	2004	BAGO	14	3	11	11	0
LOSC-5	2004	BLSC	7	3	4	3	1
LOSC-5	2004	BUFF	13	6	-	7	-
LOSC-5	2004	COGO	1	1	0	0	0
LOSC-5	2004	HADU	18	6	12	11	1
LOSC-5	2004	RBME	2	2	-	0	-
LOSC-5	2004	SUSC	2	0	2	1	1
UPSC-1	2003	BAGO	5	5	1	1	0
UPSC-1	2003	COGO	5	4	1	1	0
UPSC-1	2003	RBME	3	-	-	-	-
UPSC-1	2003	SUSC	10	3	7	7	0
UPSC-1	2004	BUFF	1	0	-	1	-
UPSC-1	2004	COME	1	0	-	1	-
UPSC-1	2004	RBME	3	0	-	3	-
UPSC-1	2004	SUSC	2	1	1	1	0
UPSC-2	2003	BAGO	21	9	12	9	3
UPSC-2	2003	BLSC	7	1	6	5	1
UPSC-2	2003	BUFF	3	-	-	-	-
UPSC-2	2003	COGO	11	4	7	7	0
UPSC-2	2003	COME	2	-	-	-	-
UPSC-2	2003	HADU	17	6	11	10	1
UPSC-2	2003	RBME	2	-	-	-	-
UPSC-2	2003	SUSC	97	27	70	68	2
UPSC-2	2003	WWSC	9	-	-	-	-
UPSC-2	2004	BAGO	9	4	5	5	0
UPSC-2	2004	BUFF	8	3	-	5	-
UPSC-2	2004	COGO	22	8	14	13	1
UPSC-2	2004	COME	2	0	-	2	-
UPSC-2	2004	HADU	19	9	10	8	2
UPSC-2	2004	RBME	1	0	-	1	-

Transect	Year	Species	Total	F	M	M_{ADU}	M_{1Y}
UPSC-2	2004	SUSC	96	35	61	58	3
UPSC-2	2004	WWSC	7	5	-	2	-
UPSC-3	2003	BAGO	6	2	4	4	0
UPSC-3	2003	BLSC	28	7	21	19	2
UPSC-3	2003	BUFF	2	-	-	-	-
UPSC-3	2003	COGO	7	2	5	5	0
UPSC-3	2003	HADU	13	6	7	7	0
UPSC-3	2003	RBME	2	-	-	-	-
UPSC-3	2003	SUSC	38	12	26	26	0
UPSC-3	2003	WWSC	23	-	-	-	-
UPSC-3	2004	BLSC	24	7	17	17	0
UPSC-3	2004	BUFF	3	1	-	2	-
UPSC-3	2004	COGO	15	4	11	11	0
UPSC-3	2004	HADU	8	2	6	4	2
UPSC-3	2004	SUSC	37	15	22	22	0
UPSC-3	2004	WWSC	11	6	-	5	-
UPSC-4	2003	BLSC	17	3	14	13	1
UPSC-4	2003	BUFF	7	-	-	-	-
UPSC-4	2003	COGO	3	1	2	2	0
UPSC-4	2003	HADU	6	3	3	3	0
UPSC-4	2003	RBME	6	-	-	-	-
UPSC-4	2003	SUSC	4	0	4	4	0
UPSC-4	2003	WWSC	46	-	-	-	-
UPSC-4	2004	BAGO	3	2	1	1	0
UPSC-4	2004	BLSC	4	0	4	4	0
UPSC-4	2004	BUFF	5	2	-	3	-
UPSC-4	2004	COGO	14	7	7	7	0
UPSC-4	2004	HADU	3	1	2	0	2
UPSC-4	2004	RBME	2	0	-	2	-
UPSC-4	2004	SUSC	10	4	6	6	0
UPSC-4	2004	WWSC	9	4	-	5	-
UPSC-5	2003	BUFF	5	-	-	-	-
UPSC-5	2003	COGO	2	1	1	1	0
UPSC-5	2003	HADU	1	0	1	1	0
UPSC-5	2003	SUSC	3	0	3	3	0
UPSC-5	2003	WWSC	11	-	-	-	-
UPSC-5	2004	BAGO	3	2	1	1	0
UPSC-5	2004	BUFF	10	4	-	6	-
UPSC-5	2004	SUSC	13	3	10	10	0
UPSC-5	2004	WWSC	32	17	-	15	-
UPSC-6	2003	BAGO	7	2	5	4	1
UPSC-6	2003	BLSC	10	2	8	6	2
UPSC-6	2003	BUFF	12	-	-	-	-
UPSC-6	2003	COGO	9	2	7	7	0
UPSC-6	2003	COME	2	-	-	-	-

Transect	Year	Species	Total	F	M	M_{ADU}	M_{1Y}
UPSC-6	2003	SUSC	10	2	8	8	0
UPSC-6	2003	WWSC	4	-	-	-	-
UPSC-6	2004	BAGO	7	2	5	5	0
UPSC-6	2004	BLSC	8	3	5	5	0
UPSC-6	2004	BUFF	3	1	-	2	-
UPSC-6	2004	COGO	7	0	7	7	0
UPSC-6	2004	HADU	2	1	1	1	0
UPSC-6	2004	SUSC	49	11	38	38	0
UPSC-7	2004	BLSC	1	0	1	1	0
UPSC-7	2004	BUFF	3	1	-	2	-
UPSC-7	2004	HADU	5	2	3	3	0
UPSC-7	2004	RBME	5	3	-	2	-
UPSC-7	2004	SUSC	10	4	6	6	0